4. Constituent and Hydraulic Loading

4.1 Soil, Water, and Hydraulic Loading

Wastewater-Land Application Permit (WLAP) sites are to be managed as agronomic units for the efficient treatment and beneficial reuse of nutrients and water while maintaining soil productivity and protecting beneficial uses of ground water. The following sections discuss soil and water principles as they relate to wastewater land treatment, and hydraulic loading of wastewater land treatment sites. Guidance related to hydraulic loading is discussed in sub-sections on both growing and non-growing season hydraulic loading.

4.1.1 Soil and Water Principles related to Wastewater Land Treatment

The ability of the soil to receive and transmit water is an important element of successful wastewater treatment through land application. The mechanisms and pathways of flow through the soil of applied wastewater and precipitation, in both the unsaturated and saturated phases, determine the initial movement and subsequent location of the waste elements. The objective of a slow rate wastewater land treatment system, whether flood or spray irrigation, is to assimilate and treat all applied wastewater and expected precipitation.

To meet the objectives associated with each treatment site, certain soil water variables must be understood. The principal soil water variable of interest is the hydraulic conductivity. Associated variables are the geological heterogeneity, topography, depth to ground water, direction of ground water flow, and soil water storage capacity. Hydraulic overloading of soil is a common cause of failure of land treatment systems. Overloading may lead to a rapid leaching of waste elements into ground water, reduction in biological activity (microorganisms, plants, etc.), associated with low gaseous exchange (sustained anaerobic conditions) soil erosion and possible contamination of surface waters.

Soil water movement, both percolation and infiltration, is highly dependent upon pore size and distribution (not necessarily porosity) of the soil. Water moves easily through interconnected large pores and slower as the pore size decreases because the resistance to water flow increases. Pore size is related to the structure and the texture of the soil however, texture alone is only an approximate indicator of general pore size. Sandy soils have relatively large pores which allow the rapid transmission of water, where clay soils have small pores with relatively slow water transmission properties.

Soils that have a high degree of swelling, relatively low electrolyte concentration and high sodium adsorption ratio, will result in small pores, even in sandy soils. Conversely, high permeability can be maintained in soils high in clay provided the clay remains in relatively large secondary aggregates through flocculation. The physical action of sprinkler irrigation can cause dispersion of surface soil aggregates and a reduction in the infiltration rate even under good flocculation conditions. Other factors that may decrease pore size in soils are clogging by microbial by-products, suspended solids and/or chemical precipitates such as ferrous sulfide. Microbial by-products and chemical precipitates are most apt to occur under anaerobic conditions. Such conditions are common to poorly managed high-rate systems. Any activity that compacts the soil surface reduces the size of the soil pores and decreases the infiltration rate. Heavy equipment like large rubber tired tractors can compact the surface and should not be used while the area is wet. Grazing of livestock may also cause soil compaction, and should be managed according to guidelines presented in Section 6.

Water application rates should not exceed the soil infiltration rate other than on level areas where runoff will not occur. Otherwise, potential pollution problems might arise. In addition, many crops are sensitive to the poor aeration that is associated with high application rates. Alfalfa, an important part of the wastewater renovation process in many areas, can be damaged by hydraulic overloading. The maximum soil infiltration capacity will have to be determined to help define the land area needed. This must take into consideration the quantity of effluent which is to be treated. This information could be established based on a test run using water similar to the sewage effluent.

In general, the total periodic (weekly) water application can be tied to the evapotranspiration and the soil water-holding capacity. By adding this amount, plus an additional quantity, the crop water requirements can be supplied. The excess water that moves beyond the root zone will likely move to the water table. A more complete picture of water movement in and out of the land treatment area is provided in Figure 4-1.

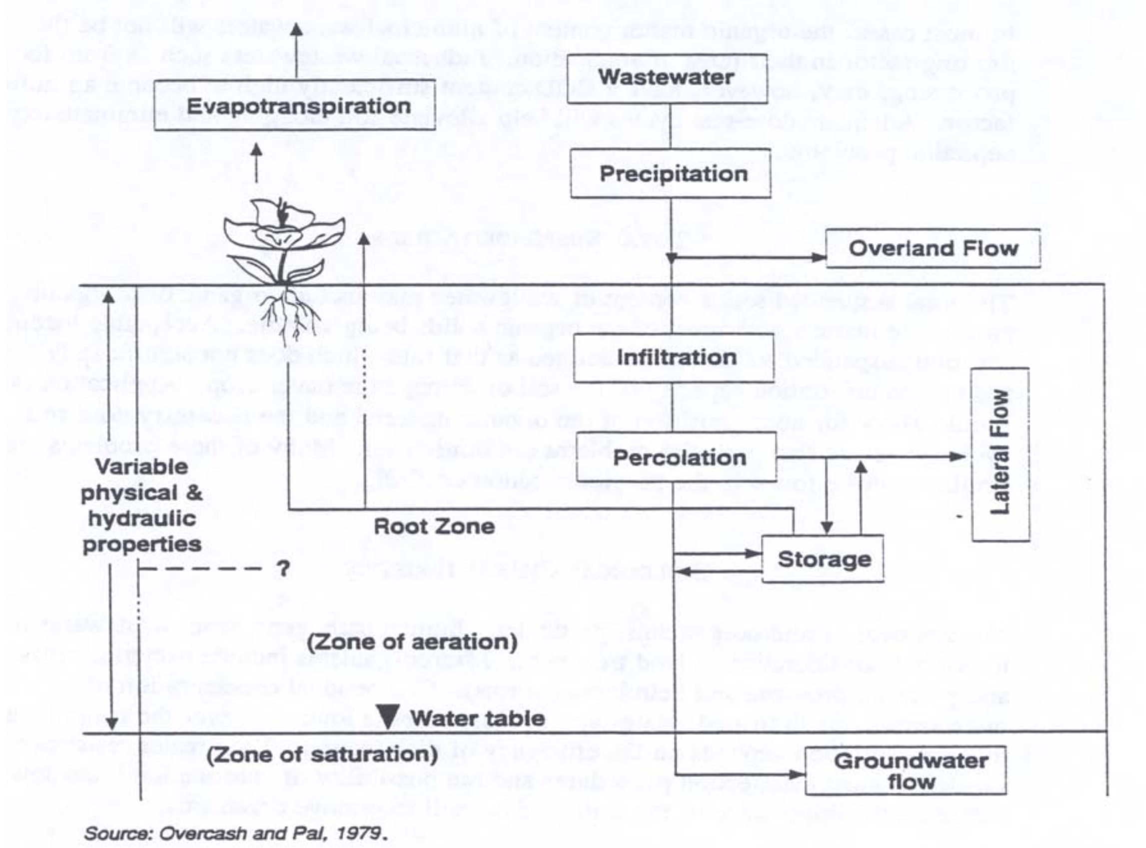


Figure 4-1. Distribution of Wastewater and Precipitation Input to Soil.

Slow-rate land application systems should result in more complete renovation of wastewater than high-rate systems. The exceptions to this observation are with nitrate and a few other substances such as boron. Slow-rate systems can use soils with much higher surface areas (silts and clays) than high-rate systems. The flow rates are therefore slower and a greater proportion of the total flow occurs in smaller pores. This situation will allow for more adsorption of components such as heavy metals and phosphorus.

4.1.2 Growing and Non-growing Season Hydraulic Loading

As previously noted, an important element of successful wastewater treatment through land-application is the ability of the soil to receive and transmit water. However, hydraulic overloading of soil is a common cause of failure of land treatment systems. This is particularly critical in winter months due to freezing conditions and the potential for ice build up. Hydraulic loading seldom poses problems during summer operation since water loss exceeds any gain from precipitation.

If the soil crop system is to be used to treat wastewater, then application rates for the most restrictive operation season will help determine the acceptable loading rates. The element that will determine the average hydraulic loading rate of each system will be based on hydrogeologic and other relevant site conditions discussed in Section 2 and elsewhere.

The following two sections provide guidance on calculating appropriate growing season and non-growing season hydraulic loading rates.

4.1.2.1 Growing Season Wastewater-Land Application

The following is a discussion of growing season wastewater-land application. It includes sections on climatic regions and growing seasons statewide, and growing season hydraulic loading rate determination.

4.1.2.1.1 Statewide Climatic Regions and Growing Seasons

The length of growing season is an important criteria when designing a wastewater-land application system. The growing season is identified by climatic conditions which vary throughout the state. For purposes of this document, the NRCS National Engineering Handbook - *Irrigation Guide*, Title 210, Chapter VI, Part 652.0408(c) and (d), September 1997. Delineates climatic regions with respect to crops and crop growth (Figure 4-2).

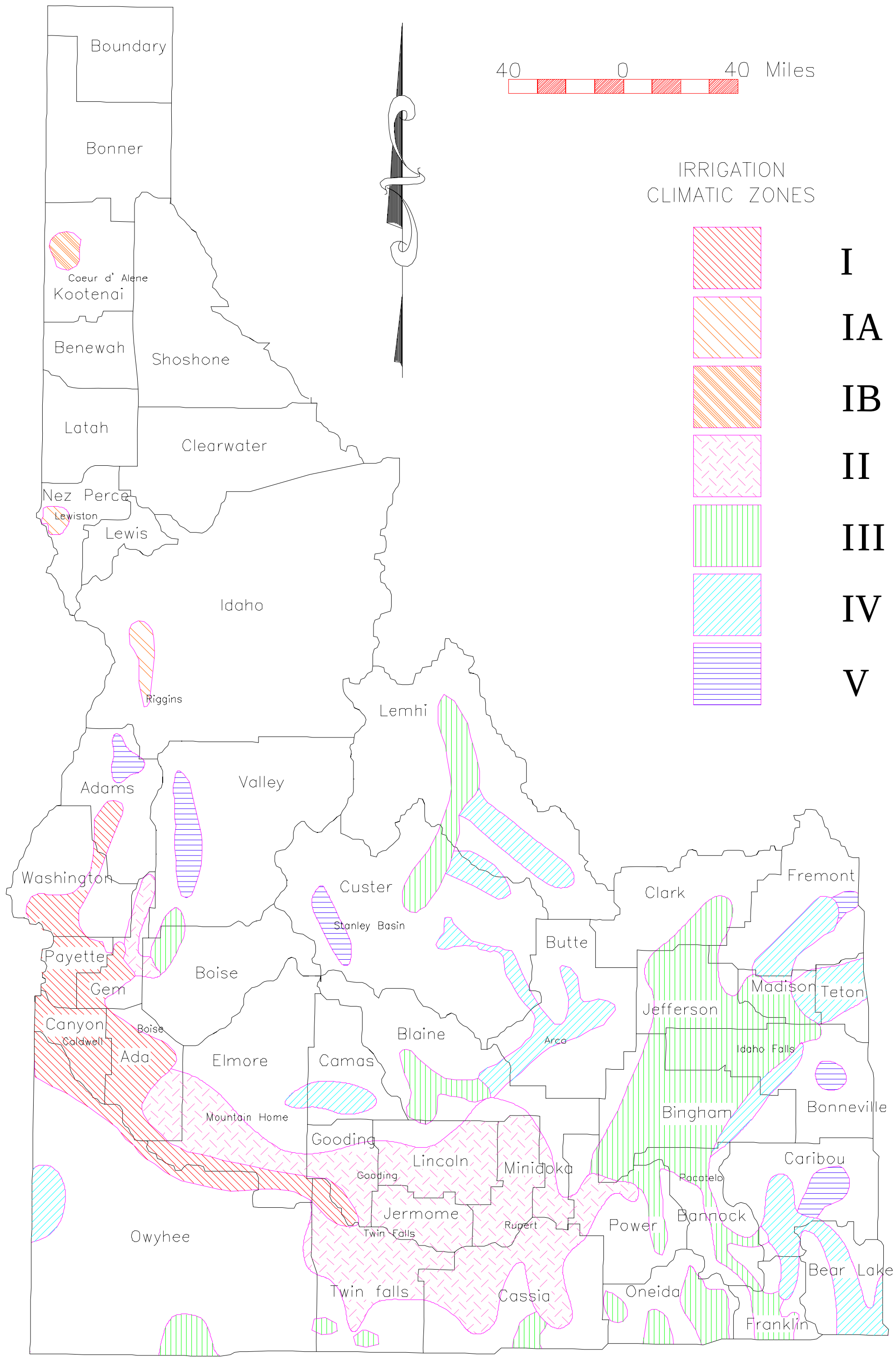


Figure 4-2. Climatic Regions in Idaho from NRCS.

Table 4-1 further describes each of the climatic regions with respect to location and key parameters for crop growth.

Additional information regarding crop growing seasons throughout the state is provided in Section 15. This information comes from the NRCS NEH Part 652.0408(c) and (d). Again, this information is not site specific, but generalized for each region. WLAP proposal designs should substantially reflect these general season lengths, with the understanding that site specific information regarding climatic, site, and management differences may be utilized.

Table 4-1. General Description of Irrigated Climatic Areas.

Irrigation Climate Area	General Location of Irrigated Climatic Areas	Frost Free Range (days)	July *f Factor Range	Representative Station			
				Station Location	Frost-Free Period (days)		July *f Factor
		32˚-32˚			32˚	28˚	
I	Lower Snake River from Weiser to Hagerman, except Mt. Home plateau. Weiser, Payette, Boise River Areas.	140 to 160	7.6 to 8.1	Caldwell	147	169	7.7
IA	Riggins, White Bird, and Lewiston	175 to 185	7.5 to 8.5	Lewiston	187	225	8.0
IB	Rathdrum Prairie Area	135 to 155	6.9 to 8.1	Coeur d' Alene	145	179	7.5
II	Snake River Plains from Mt. Home Plateau to American Falls, Including Bliss, Gooding, Shoshone, Oakley, Raft River. Middle Payette, Squaw Creek Area.	120 to 140	7.14 to 7.65	Rupert	132	158	7.46
III	Malad & Bear River Valley to Alexander, Marsh Creek and Portneuf River, Dubois, Snake river from American Falls to Chester and Heise on the South Fork, Challis to Salmon and Lower Lemhi.	100 to 120	6.84 to 7.51	Sugar City	104	128	6.98
IV	Ashton, Upper Lemhi, Pahsimeroi, Arco, Mackay, Howe, Montpelier, Grace	80 to 100	6.53 to 7.09	Arco	82	122	6.89
V	McCall, New Meadows, Stanley Basin, Greys Lake, Green Timber	50 to 80	6.62 to 6.69	McCall	59	100	6.69

*f = monthly consumptive use factor from the formula for determining water requirements for irrigated areas

The following subsections are intended to assist in the evaluation of wastewater-land application treatment design during the growing season.

4.1.2.1.2 Growing Season Hydraulic Loading Rate

Timely applications of the wastewater are needed to use the site at an optimum level. Schedules of applications will depend on crop water requirements, the strength and volume of wastewater, weather conditions, harvesting periods, and maintenance requirements. As the seasons change, the operator needs to continually evaluate the rates of application, etc., and make necessary changes in management. Good overall management of the site which includes these elements is critical in maintaining the treatment capabilities of the site.

Those systems which have slow rate infiltration and crops should be discontinued at times due to adverse weather, for maintenance purposes, harvest periods, or various other reasons. Rest periods are essential in preventing soil clogging and other adverse effects. Dose-rest cycles must be a part of the method of applying liquid wastes. It is common to use a procedure of one day of application followed by a rest period. However, actual dose-rest periods are site specific and dependent upon the characteristics of the wastewater and crop requirements. Rest periods in some cases can be as much as several weeks or months.

Hydraulic loading rates will differ for each site. Additional irrigation water can be added to meet the demands of plant growth. These guidelines are geared toward sites where wastewater is applied all year long. The wastewater application rates can be increased for seasonal (summer) use but should meet the general concepts of crop utilization and ground water protection.

Both wastewater and supplemental irrigation water should be applied at rates commensurate to the consumptive use requirements of the crop as they vary seasonally. The growing season hydraulic loading rate is the Irrigation Water Requirement (IWR) and can be defined as follows:

$IWR = IR_{net}/E_i$

Where:

IR_{net} = net irrigation requirement; the depth of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, that is required consumptively for crop production and required for other related uses. Such uses may include water required for leaching, frost protection, etc. as the following equation relates:

$IR_{net} = CU - (PPT_e + \text{carryover soil moisture}) + LR$

The monthly IR_{net} (referred to as Mean Net Irrigation Requirement, or Mean IR) may be obtained by crop type for the historic period of record (before 1983) for a particular weather station from the following web site: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

It should be noted that data compiled and provided at the web site:

http://www.kimberly.uidaho.edu/water/appndxet/index.shtml is for the historical period of record of each weather station prior to 1983, and would not reflect the historical period of record from 1983 to present.

CU = crop consumptive use. The monthly CU (referred to as Mean Monthly Consumptive Use, or Mean CU) may be obtained by crop type for the historic period of record for a particular weather station from the following web site: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

Daily CU for a particular crop and year may be obtained (and summed to generate monthly subtotals) from the USBR web site: http://www.usbr.gov/pn/agrimet/etsummary.html.

Other sources of CU information are discussed in Section 4.1.2.2. below. It is important to note that data referred to is reference evapotranspiration (ET_{ref}) which must be multiplied by an appropriate crop coefficient (Kc) to obtain CU. Kc values are not provided in this guidance.

PPT_e = effective precipitation or effective rainfall; precipitation falling during the growing period of the crop that is available to meet the consumptive water requirements of crops. It does not include such precipitation as is lost to 1) deep percolation below the root zone, 2) surface runoff, or 3) wet canopy and wet soil losses associated with irrigation events.

The monthly PPT_e for a particular weather station for the historic period of record may be derived from data provided at the following web site: http://www.kimberly.uidaho.edu/water/appndxet/index.shtml.

Specifically, $PPT_e = CU - IR_{net}$ (i.e. Mean IR). To back-calculate monthly PPT for a particular weather station for the historic period of record, divide PPT_e by 0.7. Also, Section 15 provides a table and equations for calculating PPT_e (from USDA, 1993).

LR = leaching requirement; the fraction of the irrigation water that must be leached through the crop root zone to control soil salinity at any specified level.

E_i = irrigation efficiency; the percentage of applied irrigation water that is stored in the soil and available for consumptive use by the crop. Ranges for irrigation efficiencies are given in Table 4-2 (from Follett et al. 1991). Additional irrigation efficiency information for typical irrigation systems can be found in Neibling (1998) and at the following US Bureau of Reclamation Web site:

http://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency)

Table 4-2. Irrigation Application Efficiencies

TYPE OF SYSTEM	APPLICATION EFFICIENCY
Surface	%
Furrow gated-pipe without reuse	40-75
Furrow gated-pipe with reuse	70-85
Furrow siphon tube	40-75
Graded border	50-85
Level Basin	70-85
Sprinkler	
Hand move	60-80
Solid-set	60-85
Sideroll-towline	60-80
Boom	55-75
Traveler	55-75
Center pivot	75-90
Corner pivot	70-85
Linear move	75-90
Trickle	
Point source	65-90
Lateral source	60-85

Follett et al., 1991

4.1.2.2 Non-Growing Season Wastewater-Land Application

The following section includes a general discussion of non-growing season wastewater land application, determining non-growing season loading rates, and a discussion of criteria for granting exceptions to non-growing season loading guidance.

4.1.2.2.1 Non-Growing Season Wastewater-Land Application – General Discussion

Some sites may wish to treat wastewater during the non-growing season, necessitating that loading capacity be calculated separately from growing season loading rates. Other sites may hold wastewater during the non-growing months which requires storage pond design criteria be submitted to DEQ for review and approval. Non-growing season loading and storage present economic challenges as land, treatment, and storage costs can be high.

The basic criteria used in designing non-growing season wastewater-land treatment includes but is not limited to COD loading, nutrient loading, hydraulic loading, soil, soil-water storage and climatic conditions.

Excessive non-growing season wastewater-land application may contribute to secondary contamination of the ground water or surface water resource. Excessive COD and/or hydraulic loading coupled with low temperatures that limit microbial oxidation, and uncontrollable spring thaws may cause anaerobic conditions to develop whereby an electron rich chemical environment reduces iron and manganese to mobile forms which can leach.

Generalized non-growing seasons as found in the NRCS NEH, Part 652.0408(d) and in Section 15. WLAP proposal designs should substantially reflect these season lengths, with the understanding there may be climatic, site, and management differences not reflected in and which may modify the generalized information.

Below is presented guidance for non-growing season wastewater-land application site design.

4.1.2.2.2 Non-growing Season Hydraulic Loading Rate (HLR_{ngs})

This section provides guidance on determining non-growing season hydraulic loading rates (HLR_{ngs}), which in theory allows for no leaching. The method provided below yields rates which, in general, are environmentally protective. However, the appropriateness of the guideline value obtained must be evaluated on a case-by-case basis. The HLR_{ngs} is defined as follows:

$HLR_{ngs} = [AWC + E - PPT_{ngs}] + LR$

Where:

AWC = available water holding capacity of the soil to 60 inches or root limiting layer, whichever is shallowest. Note these are general and readily obtainable numbers based on physical soil properties which presumably do not change, rather than on crop rooting depth, which changes as the crop changes. Soil AWC information may be found in National Resource Conservation Service (NRCS) Soil Survey Reports. Spatial and aspatial data (including soil AWC) may be down-loaded from the following NRCS web site: http://www.ftw.nrcs.usda.gov/ssurgo_ftp3.html.

Note that variability of soils on a hydraulic management unit generally means variable AWCs as well. In some cases, an acreage weighted average AWC may be an appropriate estimate for the unit. In other cases, selecting an AWC from the most limiting soil of reasonable a real extent may be the more environmentally protective. Such determinations need to be done on a case-by-case basis.

PPT_{ngs} = average precipitation falling during the non-growing season. Non-growing seasons are listed by crop in Section 15.8 below**.** Crop consumptive use information found in Section 15.8 should not be used. Mean monthly precipitation (thirty year averages) for weather stations in Idaho are found in Section 15.9 below. The period of record for data in Section 15.9 is dated (1961-1990). More recent average precipitation data (1991 to 2002) may be found in AgriMet summary spreadsheet tables found in DEQ Intranet site G:\Wastewater Common-Drive\TGR Project\Project Area|Section 1.1\AgriMet summary SSs|. Also, average precipitation data from1948 to present may be found at the Desert Research Institute – Western Regional Climate Center web site: http://www.wrcc.dri.edu/summary/climsmid.html.

PPT_e should not be used when calculating NGS hydraulic balances. Non-growing season ET losses are reckoned to account for non-leaching and non-runoff PPT losses.

E = estimate of evaporation/evapotranspiration during the non-growing season. This guidance recommends three sources for E estimates:

1) Lysimeter measurement of non-growing season ET for the Kimberly area is found in Wright (1991~~3~~). For WLAP facilities near Kimberley ID, results of Wright (1991) can be utilized.

2) Non-Averaged NGS ET Data: Non-growing season ET data (for bare wet soil) for different weather stations may be found at the AgriMet Historical Archive Weather Data Access Web Site: *http://www.usbr.gov/pn/agrimet/webarcread.html*. These values are calculated using the 1982 Kimberly-Penman Equation as modified in Wright (1996) (Dr. James Wright, Personal Communication; August 20, 2003). Daily ET data for time periods between 1991 and present may be down-loaded. In order to obtain historical monthly averages of non-growing season ET, down-loaded data from the period of record must be manipulated in a spreadsheet so that data may be summed and averaged by month. Data from a single year of record should not be utilized to determine non-growing season ET. After monthly average values of ET are calculated, they should be multiplied by an 'evaporation coefficient' of 0.7 to account for snow cover and dry soil surface conditions (J. Wright, August 20, 2003).

3) Averaged ET Data: Averaged summary non-growing season ET data (1991 to 2002) may be found in AgriMet summary spreadsheet tables found in DEQ Intranet site G:\Wastewater Common-Drive\TGR Project\Project Area|Section 1.1\AgriMet summary SSs|. These average data must also be multiplied by an 'evaporation coefficient' of 0.7 as discussed above.

LR = Leaching requirement: See definition in Section 4.1.1.2.1 above. It is generally observed that soil EC levels from wastewater land application sites do not show increases over time, which increases would indicate salt build-up. Soil EC levels usually reflect agronomically acceptable ranges (i.e. which would not cause crop yield decrements). Apparently there is sufficient leaching taking place both through normal agronomic practices employed at wastewater land application sites, and at sites practicing non-growing season application. DEQ allows the inclusion of a leaching requirement if soil EC data indicate salt build-up.

In addition, non-growing season hydraulic loading should conform to the following guidelines:

1. Wastewater should not be applied on frozen soils where frozen soil is defined as 0° centigrade or less in the upper six inches of soil.
2. Wastewater should not be applied when it will freeze and accumulate on the surface of the soil. This is to avoid spring thaw conditions which could overload the soils both hydraulically and with respect to COD. This is also intended to avoid potential for runoff which will not ensure adequate treatment for COD and could result in phosphorus contamination of surface water.
3. Wastewater should be applied evenly over the non-growing season site. The site should be sprinkler irrigated with winterized equipment; flood or furrow generally results in prolonged saturated conditions causing both the development of reducing conditions and leaching in the spring.

4.1.2.2.3 Criteria For Granting Exceptions To Non-Growing Season Loading

An applicant or permittee may wish to design a system with non-growing season loading rates that exceed the basic criteria and guidance given above. Any request for an exception to the basic criteria must still achieve programmatic objectives of protecting public health and preserving the beneficial uses of surface and ground water. Such requests must demonstrate that non-growing season wastewater-land application:

- will not cause projected impacts to ground water or prolonged anaerobic conditions to develop in the soil or aquifer, such that the flux of redox sensitive constituents and soluble organics beyond the crop root zone does not cause an exceedance of the primary or secondary water quality standards;

- will be conservative enough to handle a variety of demanding case scenarios including late winter/early spring thaw or precipitation events without runoff, hydraulic overloading, or other crisis conditions;

- will not create or contribute to nuisance conditions or adversely affect public health;

- will be conducted utilizing either best practical methods, approved best management practices, or best available technology, whichever most effectively minimizes impacts to ground water and surface water.

4.1.3 References

Follett, R.F., Keeney, D.R., and Crose, R.M., 1991. Managing Nitrogen for Ground Water Quality and Farm Profitability.

Neibling, Howard. August 1998. Introduction to Irrigation System Planning and Management. Biological and Agricultural Engineering Department. University of Idaho.

USDA - National Resource Conservation Service. National Engineering Handbook - Irrigation Guide, Title 210, Chapter VI, Part 652, September 1997.

USDA National Resource Conservation Service. National Engineering Handbook - Irrigation Water Requirements, Title 210, Chapter VI, Part 653.0207e. September 1997.

Wright, J.L. 1996. Derivation of Alfalfa and Grass Reference Evapotranspiration. In. Evapotranspiration and Irrigation Scheduling, C.R. Camp, E.J. Sadler, and R.E. Yoder (ed.). Proc. Int. Conf., ASAE, San Antonio, TX. pp. 133-140.

Wright, J.L. 1991. Using weighing lysimeters to develop evapotranspiration crop coefficients. Lysimeters for evapotranspiration and environmental measurements. Proc., 1991 International Symposium on Lysimetry, ASCE, New York, NY, 191-199.

4.2 Nitrogen

Nitrogen is an important constituent of wastewater and may be one of the main limiting factors in designing a system for wastewater treatment by land application. Therefore, the assimilative capacity for nitrogen is an important part of the design of a land treatment system. Nitrogen removal can be very efficient in the soil crop system.

Nitrogen is lost or removed from soil systems through several mechanisms including ammonia volatilization, denitrification, crop uptake and harvest, and leaching. One of these mechanisms, denitrification, requires anaerobic conditions, yet the soil plant system requires an aerobic environment. Aerobic conditions in the root zone and occasional anaerobic conditions below the root zone promote denitrification.

On a land application site, efforts must be made to control the leaching and runoff losses of nitrogen compounds. Conditions of rapid water movement beyond the root zone, which can occur with excess water application to soils, can lead to increased nitrate levels in ground water. The basic approach to reduce leaching is to have a crop that will retain or use the nitrogen. This will help prevent excess nitrate accumulation and potential leaching problems and subsequent ground water pollution. The basic approach in controlling runoff is to implement best management practices at each site.

4.2.1 Nitrogen Chemistry

Nitrogen in the wastewater effluent can be found in both inorganic and organic forms. Inorganic forms include ammonium (NH_4^+), ammonia (NH_3), nitrite (NO_2^-), and nitrate (NO_3^-). Ammonium ion (NH_4^+) tends to remain in the soil and can be held in the soil on clay and organic matter cation exchange sites. It can be utilized by both plants and microorganisms as a nitrogen source. Nitrogen in the NH_3 form may be lost from the system as a gas through volatilization. NO_2^- is a highly mobile anion and is an intermediate during the microbial conversion of ammonium to nitrate. It can be toxic to higher plants. NO_3^- is readily used by both plants and microorganisms. This highly mobile anion is of primary interest because of its potential impacts on ground water quality.

Organic nitrogen is bound in carbon containing compounds. Examples of organic forms are nucleic acids, proteins (enzymes) and amino acids. Organic nitrogen is generally not available for direct plant uptake. An aerobic environment allows the transformation of organic nitrogen to NH_4^+ and NO_3^-.

Nitrogen in wastewater may undergo oxidation-reduction reactions when they are added to the soil. These reactions are especially important in the case of nitrogen since it is potentially a serious pollutant in wastewater and its behavior in the soil is highly dependent on its state of oxidation. Organic nitrogen is mineralized to form NH_4^+ or NH_3. In aerated soil, NH_4^+/NH_3 is nitrified and converted to NO_3^- and will move with the wetting front. Under anaerobic soil conditions NO_3^- will be reduced to atmospheric nitrogen (N_2) and gaseous oxides nitrogen (NO_x). N_2 and NO_x tend to be lost from the system as gases (Figure 4-3).

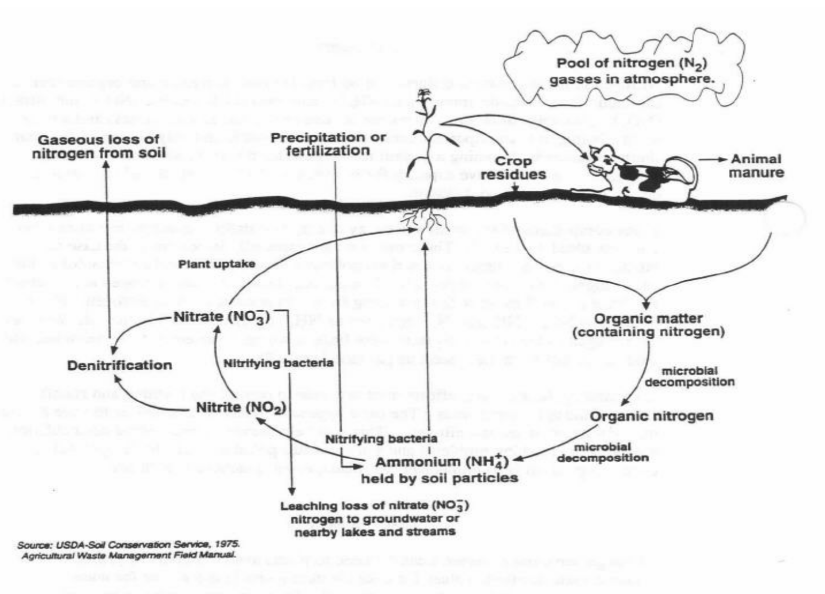


Figure 4-3. General Nitrogen Cycle.

4.2.2 Nitrogen Loading

The nitrogen loading rates depend upon a number of factors. The main factor is the requirement that the nitrate nitrogen levels of ground water outside the property boundaries of the application system do not exceed the water quality standard of 10 mg/L. (See Section 7). Ground Water Monitoring for more information). The previous section describes the different forms of nitrogen and how they can become nitrate. It is therefore important to know the levels of organic nitrogen, ammonium (NH_4), and nitrite (NO_2^{-1}) in addition to nitrate. The land application system must be operated in a manner that removes nitrogen based on the forms of nitrogen which are known to occur.

To help ensure the protection of ground water, keeping in mind that the wastewater application site is for treatment purposes, a nitrogen application rate should be established. These guidelines recommend that nitrogen loading rates be based on crop utilization plus 50 percent. The excess is provided for normal losses of applied nitrogen over the needs of the crop. Additional irrigation water should be adequate to allow for maximum plant growth and eventual harvest. Crop testing for nitrate as N should be conducted to prevent nitrate poisoning. Tables in Section 7 give examples of nitrogen demands and typical crop uptake for selected crops.

4.2.2.1 Non-Growing Season Nutrient Loading Rate (NLR_{ngs})

Nutrient loading of wastewater-land application sites should be commensurate with crop needs, uptake, and efficiency of crop uptake. Non-growing season applications should be made so that applied nutrients are stored in the soils to be available during the growing season. Justification for nutrient loading should demonstrate leaching of nutrients in rates and amounts which substantially protect beneficial uses of ground water. As with growing season loading rates, potential or actual effects on ground water should be below water quality standards.

One example to calculate non-growing season Nitrogen Loading Rate (NLR_{ngs}) follows:

$NLR_{ngs} = (N_{crop} * 1.5) - N_{gs}$

Where:

N_{crop} = *crop nitrogen requirement*

N_{gs} = *nutrient load applied during the growing season*

4.2.2.2 Growing Season Nutrient Loading Rate (NLR_{gs})

As stated above, general rates for nitrogen loading are 150% of crop uptake. This approach does not take into consideration nitrogen resident in the soil profile, or nitrogen needs as a function of yield goal. Other major nutrient needs such as phosphorus and potassium are addressed in the University of Idaho crop nutrient guides (see also Section 4.9 below for further discussion of phosphorus). The University of Idaho crop nutrient guides or demonstrated agronomic utilization may also be utilized to help determine appropriate nutrient loading rates. Whichever approach is chosen should maintain ground water quality so that appropriate water quality standards are not exceeded. Spring soil testing is generally needed to determine resident nutrients (nitrogen in particular) at the beginning of the season, in order to calculate how much the management unit should be loaded.

4.2.2.3 Determining Nitrogen Loading Limit Compliance

Standard WLAP permit templates for municipal sites include limits on the amount of nitrogen that can be applied to the land application site.

The WLAP permit limits are as follows:

Parameter	Permit Limit
Total Nitrogen	150 of typical crop uptake; 150% of uptake values from standard tables; or Use of University of Idaho Fertility Guides.

In order to determine compliance with 150% of typical crop uptake, take the following steps:

1. Calculate the nitrogen uptake by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of data plant tissue data. Select the median value from these data and multiply by 1.5. This is the loading limit. (in pounds per acre)

   To determine the permit limit for nitrogen using standard tables, find the crop type in Section 7 and look up the nitrogen content. Then multiply by crop yield (per acre) and by 1.5. This is the loading limit based on a standard table. If the crop grown at the site is not included in Section 7, contact DEQ to get nutrient uptake for the crop being grown.

   Note that the permit limit may change from year to year if the crop type changes or the crop yield changes.

2. Calculate the amount of nutrients applied by wastewater application or from other sources, such as supplemental fertilizers. (in pounds per acre). To make this calculation, the following information is required:
   a. Volume of wastewater applied, gallons/year
   b. Wastewater quality in mg/l. Use total nitrogen (sum of Total Kjeldahl Nitrogen and Nitrite+Nitrate Nitrogen)
   c. The amount of supplemental fertilizer applied or any other nutrient sources (pounds per acre)
   d. Calculate wastewater N loading from wastewater volume, concentration, and site acreage, and then sum fertilizer loading rate to obtain total N loading.
3. Compare the permit limit calculated in Step 1 above to the amount of nitrogen applied calculated in Step 2 to determine compliance.

   Example calculations are provided below.

4.2.2.4 Example Calculations

Example 1

Crop type:	Alfalfa Hay
Crop yield:	4.5 tons/acre
Wastewater applied to land application field:	6 million gallons
Land application area:	20 acres
Wastewater total nitrogen:	20 mg/l (ppm)

No supplemental fertilizer applied

1a. Calculate crop uptake of nitrogen
For alfalfa hay, the nitrogen uptake (from Table 7-26 Section 7) is 50.4 pounds per ton of yield.
Nitrogen uptake: 4.5 tons/acre x 50.4 pounds N/ton = 226.8 pounds/acre

1b. Calculate the nitrogen permit limits (150% of crop uptake)
Nitrogen application permit limit: 226.8 x 1.5 = 340 pounds/acre
(round off to nearest whole number)

2. Calculate the amount of nitrogen applied with the wastewater

$$\text{Nitrogen: } \frac{6\text{ MG}}{\text{year}} \times 20\text{ mg/L N} \times \frac{8.34\text{ pounds/MG}}{1\text{ mg/L}} \times \frac{1}{20\text{ acres}} = \frac{50.0\text{ lbs Nitrogen}}{\text{acre}}$$

3. Compare nitrogen applied versus the permit limit to determine compliance.

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	340 pounds/acre	50 pounds/acre	Yes

Example 2

Crop type:	Forest Site (pine tree)
Crop yield:	Harvest per silvicultural plan
Wastewater applied to land application field:	14 million gallons
Land application area:	26 acres
Wastewater total nitrogen:	15 mg/l (ppm)

No supplemental fertilizer applied

1a. Calculate crop uptake of nitrogen
From Table 7-26, Section 7, for tree sites, the nitrogen uptake allowance is up to 220 pounds per acre.

1b. Calculate the nitrogen permit limits (150% of crop uptake)
Nitrogen application permit limit: 220 x 1.5 = 330 pounds/acre
(round off to nearest whole number)

2. Calculate the amount of nitrogen applied with the wastewater

$$\text{Nitrogen: } \frac{14\text{ MG}}{\text{year}} \times 15\text{ mg/L N} \times \frac{8.34\text{ pounds/MG}}{1\text{ mg/L}} \times \frac{1}{26\text{ acres}} = \frac{67.4\text{ lbs Nitrogen}}{\text{acre}}$$

3. Compare nitrogen applied versus the permit limit to determine compliance

	Permit Limit 150% of crop uptake	Amount applied	In compliance with permit limit?
Nitrogen	330 pounds/acre	67.4 pounds/acre	Yes

4.3 Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS)

This section discusses both chemical oxygen demand (COD) and total suspended solids (TSS) as they relate to wastewater land treatment. These two constituents are related and, in certain respects, are descriptive of similar chemical characteristics and influence on the crop-soil system, as will be discussed below.

4.3.1 Chemical Oxygen Demand (COD)

The following section discusses COD assimilative capacity in the soil system, soil chemistry and oxygen demand, and both growing and non-growing season COD loading guidelines for wastewater land treatment sites.

4.3.1.1 Soil COD Assimilative Capacity

Soil has long been identified as a good medium for the assimilation of the organic matter in wastes. A common measure of organic matter is chemical oxygen demand (COD). This is a particularly useful measurement when considering factors influencing the soil chemical environment. The degree of oxygen demand imposed upon the soil system is an important factor in determining to what degree the soil is aerobic or anaerobic, and what chemical processes would be taking place in the system.

The upper limit on the amount of COD that a soil can assimilate depends largely on the environmental conditions and the nature of the waste applied. The major elements which affect the decomposion of organic matter applied to the soil are: 1) carbon:nitrogen ratio; 2) oxygen supply; 3) temperature; 4) soil moisture content; 5) pH; and 6) salinity. Soil should not be saturated for extended periods in order to keep oxygen levels up. Certain moisture levels are needed for optimum bacterial decomposition. The rate of decomposition increases with increasing temperature, with about 38ºF being very slow and maximum rates occurring around 80ºF. Bacteria, which are the most effective waste decomposers, function best in soils with a pH range of 6.5-8.5 which are neutral to slightly alkaline. High levels of salinity can reduce COD removal by organisms in the soil.

Of the many benefits resulting from the application of organic matter to the soil, one is the binding of soil particles together into aggregates (aggregation). Microbial decomposition end products include compounds which promote aggregation. This helps produce more pore space in the soil and may result in improved aeration and increased infiltration capacity.

Soil clogging associated with high COD loadings, can severely limit the function of a site to treat wastewater. The conditions that could cause such a problem should be evaluated in order to understand the capacity of soil for wastewater treatment. Clogging can result from biochemical reactions, excessive loading of organic and inorganic materials (both dissolved and particulate), excessive hydraulic loading, and the physical properties of the soil surface and profile.

Clogging generally occurs in the top few inches of soil. This can be seen as a function of the organic mat that is largely independent of the coarseness of the soil. The continued existence of anaerobic conditions in the soil surface layer can lead to clogging. Anaerobic conditions result in a low rate of biological activity. This can result in sludge accumulation and production of ferrous sulfide.

In most cases, the organic matter content of municipal wastewaters will not be the limiting factor in their rates of application. Industrial wastewaters such as from food processing, may, however, have a COD content sufficiently high to become a limiting factor. With the application of high strength wastewaters, oxygen may be quickly depleted. If the soil pores have been clogged by wastes or are waterlogged, the diffusion of air is restricted, the rate of decomposition is lowered and the chemical end products will differ. Some of these by-products cause nuisance odors. Odors can be controlled however by maintaining conditions favorable to aerobic (oxygen present) waste decomposition. Under anoxic (oxygen absent) conditions, some elements within the soil, such as iron and manganese, can be reduced to soluble and mobile forms.

In order to help maintain aerobic conditions within the soil and to prevent associated problems, the yearly average organic loading rate should not exceed 50 pounds COD per acre per day. These guidelines are based on the application of wastewater all year long. This application rate is most commonly tied to the related nitrogen concentrations. The wastewater application rates can be increased for seasonal (summer) use but should be at or below soil assimilation rates, and at rates to insure ground water protection. Adequate dose-rest cycles will help alleviate soil clogging and eliminate oxygen depletion problems.

4.3.1.2 Non-Growing Season COD Loading Rate

The COD loading of wastewater-land application sites during the non-growing season , according to the *Guidelines*, is to be less than 50 lbs/acre/day based on a non-growing season average. There may be cause to reduce this rate if the site is flood irrigated.

Justification for proposed COD loading during the non-growing season should be made for loadings near guideline rates. Such justification may reference empirical data (what has worked, or what has not), and/or may involve more theoretical approaches which take into consideration oxygen diffusion rates into soil, re-aeration times, soil porosity, temperature, and irrigation scheduling (Carlisle and Phillips, 1976).

4.3.1.3 Growing Season COD Loading Rate

COD loading during the growing season, compared to non-growing season loading, is generally a less constraining design parameter. Nevertheless, justification for loadings in excess of the guideline rate of 50 lb/acre/day (based on a growing season average) should be provided as described in the Non-Growing Season COD Loading Rate section.

4.3.2 Total Suspended Solids (TSS)

The total suspended solids content of wastewater may include organic or inorganic particulate matter, with most of the organic solids being volatile. Many of the concerns related to the chemical oxygen demand of the wastewater and related problems with loading rates apply to total suspended solids. Loading rates for total suspended solids need to be carefully evaluated. Acceptable loading for total suspended solids can be defined as that rate which does not significantly reduce the infiltration capacity of the soil or damage the cover crop. Application rates should allow for decomposition of the organic material and the necessary dose-rest cycles to assure that potential problems are minimized.

Although organic solids can be almost completely removed by land application, problems with odors, ponding, insects and damage to cover crops can develop. Excess solids loadings could result in a solids build-up on top of the soil causing reduced infiltration rates. To prevent soil clogging, it is necessary to apply wastewater intermittently, allowing drying or resting periods between applications to permit the infiltration rate, which decreases during application, to recover during the drying cycle. The higher the total suspended solids content of the wastewater, the faster the soil will clog and the more frequent it should dry.

The method of wastewater application will, to some extent, determine the amount of solids that can be applied to a field. Generally, spray irrigation is better suited for the application of more solids per acre than flood irrigation, due to the even distribution of solids. However, the nature of the solids and method of distribution will highly influence the rate of application.

4.4 Trace Elements

Trace elements may be of importance in wastewater land treatment systems. Trace element removal in the soil system is a complex process involving the mechanisms of adsorption, ion exchange, precipitation, and complexation. Adsorption of most trace elements occurs on the surfaces of clay minerals, organic matter, and metal oxides. Cationic Species are generally adsorbed, whereas anions tend to be repelled from these same surfaces. This makes for differences in the rate at which applied anions and cations move through the soil.

Cations that are fixed in exchangeable forms generally remain in place until replaced by another cation. The ability of a soil to retain various cations in exchangeable form depends on several factors, with degree of hydration and valence or charge of the cation being among the most important. On the other hand, anions tend to move with water and generally accumulate near the head of any wetting front of water moving through the soil.

The magnitude of the exchange reactions depends upon the cation exchange capacity (CEC) of the soil which is a function of the type and quantity of clay and organic matter. In general, soils with more clay and organic matter have higher CEC's, and have a larger adsorption capacity for trace elements than sandy soils. Such soils have a resulting higher cation retention capacity. Soils with clayey textures may have infiltration problems and associated drainage and crop growth problems. Soils with substantial content of shrink-swell clays can pose problems for engineered structures as well as have agronomic problems.

Although some trace elements can be toxic to plants and consumers of plants, no accepted toxic threshold values for additions to soil have been established. Ceiling concentrations, annual loading levels, and maximum loadings over the life of a land treatment system for several trace elements (see Tables 1 through 3) have been prescribed in 40 CFR 503.13 Subpart B: Land Application for land applied sewage sludge. In addition, toxicity problems can be reduced by maintaining the soil pH above 6.5.

Removal of trace elements from wastewater normally occurs through sludge generation during initial treatment. For example, effluent from domestic sewage contains very small concentrations of the most toxic metals such as cadmium. The remaining trace elements are nearly all removed in soils suitable (high CEC) for slow rate systems. Therefore in many land treatment systems, trace element removal will not be a limiting factor.

Title 40: Protection of Environment
PART 503—STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE
Subpart B—Land Application

§ 503.13 Pollutant limits.
(a) Sewage sludge. (1) Bulk sewage sludge or sewage sludge sold or given away in a bag or other container shall not be applied to the land if the concentration of any pollutant in the sewage sludge exceeds the ceiling concentration for the pollutant in Table 1 of §503.13.
(2) If bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site, either:
(i) The cumulative loading rate for each pollutant shall not exceed the cumulative pollutant loading rate for the pollutant in Table 2 of §503.13; or
(ii) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of §503.13.
(3) If bulk sewage sludge is applied to a lawn or a home garden, the concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of §503.13.
(4) If sewage sludge is sold or given away in a bag or other container for application to the land, either:
(i) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of §503.13; or
(ii) The product of the concentration of each pollutant in the sewage sludge and the annual whole sludge application rate for the sewage sludge shall not cause the annual pollutant loading rate for the pollutant in Table 4 of §503.13 to be exceeded. The procedure used to determine the annual whole sludge application rate is presented in appendix A of this part.
(b) Pollutant concentrations and loading rates—sewage sludge.—

Table 4-3. Ceiling Concentration, Cumulative Pollutant Loading Rates, Pollutant Concentrations, Annual Pollutant Loading Rates for 40 CFR 503.13.

(Table 1 of § 503.13_Ceiling Concentrations)

Pollutant	Ceiling concentration (milligrams per kilogram) \1\
Arsenic	75
Cadmium	85
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420

Selenium	100
Zinc	7500

\1\ Dry weight basis.

(2) Cumulative pollutant loading rates.

Table 2 of § 503.13_Cumulative Pollutant Loading Rates

Pollutant	Cumulative pollutant loading rate (kilograms per hectare)
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

(3) Pollutant concentrations.

Table 3 of § 503.13_Pollutant Concentrations

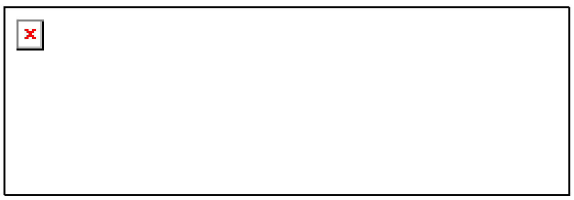
Pollutant	Monthly average concentration (milligrams per kilogram) \1\
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

\1\ Dry weight basis.

(4) Annual pollutant loading rates.

Table 4 of § 503.13_Annual Pollutant Loading Rates

Pollutant	Annual pollutant loading rate (kilograms per hectare per 365 day period)
Arsenic	2.0
Cadmium	1.9
Copper	75
Lead	15
Mercury	0.85
Nickel	21
Selenium	5.0
Zinc	140



(c) Domestic septage. The annual application rate for domestic septage applied to agricultural land, forest, or a reclamation site shall not exceed the annual application rate calculated using equation (1).

Where:

AAR=Annual application rate in gallons per acre per 365 day period. N = Amount of nitrogen in pounds per acre per 365 day period needed by the crop or vegetation grown on the land.

[58 FR 9387, Feb. 19, 1993, as amended at 58 FR 9099, Feb. 25, 1994; 60 FR 54769, Oct. 25, 1995]

4.5 Salinity and Sodium Influences

There are a number of potential problems associated with soluble salts and sodium in wastewater when applied to the soil. This section discusses both salinity and sodium influences from wastewater land application to wastewater land treatment sites.

4.5.1 Salinity

High levels of salt in the soil solution may reduce the yield of vegetation or crops grown on the site and adversely impact soil structure which can significantly reduce soil permeability. In most cases salinity will not be a limiting factor. However, consideration~~s~~ should be given to the influence of salt loading to wastewater land treatment sites.

Salinity effects on plants are categorized as: 1) ionic interference; 2) changes in osmotic or diffusional relationships; and 3) toxicity of chemical species. Wastewater high in salts when applied to land can raise the osmotic pressure of the soil solution. The result is that the level in osmotic potential between the soil solution and root cells is reduced such that there is less water uptake by plants. The visible effects of excess salinity are reductions in both total plant size and the rate growth. Salt-affected plants do not respond to the application of fertilizers because they further increase the osmotic potential of the soil solution and compound the salinity effects.

The salinity of wastewater can be estimated from its electrical conductivity. Electrical conductivity is in turn related to total dissolved solids by the following general equation: TDS = 0.64 * EC. Each wastewater will have a unique TDS/EC relationship depending upon content of soluble organic or other non-charged species, and type and activity of soluble salts among other factors. It is advisable to irrigate with wastewater, or wastewater/irrigation water mix, which has an electrical conductivity which would not cause foliar burn, plant toxicity, yield decrement etc. USDA Agriculture Handbook No. 60 (February 1954) Figure 25 and associated text discusses salinity classifications of irrigation waters and their respective hazards, based upon EC levels. Also shown in Figure 25 are classifications of sodium hazards of irrigation waters, based upon SAR levels (see further discussion below). This reference should be consulted when evaluating loading onto wastewater land treatment sites. See the following Web site for further information: http://www.ussl.ars.usda.gov/hb60/offset/Hb60ch5.pdf. See also Tanji (1990) for a more recent text.

4.5.2 Sodium Influences

For a wastewater land application site, the concentrations of sodium (Na), magnesium (Mg) and calcium (Ca) are interrelated and can be controlling factors in the treatment method. The importance of Na, Ca, and Mg is due to their impact on soil structure, which is the major determination for water movement and wastewater treatment. Soils with high levels of exchangeable sodium are called sodic soils, and are defined as soils with sodium adsorption ratio (SAR) values >15 (Bohn, et al. 1979). See further discussion of SAR below. For most crops grown on land treatment sites, Soil SAR values of less than 10 are acceptable. It has been shown that occasional problems may be encountered where SAR values are over 10. High Na in wastewater will displace Ca and Mg from the soil exchange sites, leaving high Na concentrations in the soil. Excessive sodium in soils can promote deflocculation of the soil colloids and swelling of the clay fraction of the soil. Soil structure collapses and water movement becomes severely restricted. A lowering of hydraulic conductivity reduces the water intake and transmission capacity at a site. Such reductions in soil permeability should be avoided.

The degree to which sodium influences soils, and thus the degree to which SAR indicates infiltration problems, is soil-specific. For example, coarse-textured soils like sands are generally less affected by exchangeable sodium than are fine-textured soils such as clays. Soils containing clay of the expanding type, such as montmorillonite, swell and disperse at an increasing rate with increased soil sodium levels.

Since Na, can cause soil structure problems, the levels of Na, Ca and Mg should be determined in the soil profile. An index of sodium influence of both waters, wastewaters, and soils is the sodium adsorption ratio (SAR). The equation for SAR is as follows:

$$\mathrm{SAR} = \frac{\mathrm{Na}}{(\mathrm{Ca} + \mathrm{Mg})/2 \text{ ^}0.5}$$

where Na, Ca and Mg are measured in milli-equivalents per liter in a soil solution extract or water sample (See Section 7 for further information). Exchangeable sodium percentage (ESP) is another measure of the Na content on soil exchange sites in the soil system relative to the other cations.

4.5.3 References

Bohn, H. L., B. L. McNeal, and G. A. O'Connor. 1979. Soil Chemistry. John Wiley and Sons. 329 pages.

Tanji, K. K. (ed.). 1990. "Agricultural Salinity Assessment and Management", In: ASCE Manuals & Report on Engineering Practice No. 71, 1990. 762 Pages. American Society of Civil Engineers.

United States Department of Agriculture. Agricultural Handbook No. 60. Saline and Alkalai Soils - Diagnosis and Improvement. February 1954.

4.6 Hazardous Wastes

Land application of wastewaters containing hazardous wastes will not be allowed unless the type, concentration and amount can be identified and determined that it is not regulated as hazardous waste, and will not adversely affect the beneficial uses of waters of the State or public health. . In situations where the nature of the wastewater is such that it is not regulated by the regulations discussed below, an evaluation of the suitability for treatment by land application will be made by the Department of Environmental Quality (DEQ) on a case-by-case basis. The key element that determines the feasibility of land application as a wastewater treatment alternative is the ability of the soil crop system to treat, not just dispose, of the wastewater in question.

Land application systems are subject to the Idaho Hazardous Waste Management Act (HWMA) of 1983 and the Rules and Standards for Hazardous Waste IDAPA 58.01.05. The primary purposes of the Federal Resource Conservation and Recovery Act (RCRA) is to provide "cradle to grave" management of hazardous wastes, solid wastes, and regulation of underground storage tanks. Hazardous wastes are subject to regulation in their generation, transport, treatment, storage and disposal under RCRA, Subtitle C. In Idaho, DEQ has primacy to administer the hazardous waste (RCRA) program under the HMWA. Please direct any inquiries regarding testing requirements to determine if a waste is hazardous or any other aspect of managing hazardous wastes to RCRA/HWMA DEQ personnel. Other information pertaining to hazardous waste is included in Section 12 *Information Packet for the Management of Pumpable Wastes*.

Underground storage tanks are regulated according to their contents. RCRA, Subtitle C regulates those underground storage tanks that contain hazardous wastes. The 1984 Amendments to RCRA added Subtitle I, which regulates underground storage tanks containing chemical and petroleum products. Contact DEQ with questions regarding underground storage tanks containing hazardous wastes or questions regarding the requirements for underground storage tanks containing chemical or petroleum products.

The Rules Regulating the Disposal of Radioactive Materials not Regulated under the Atomic Energy Act of 1954, as Amended IDAPA 58.01.10 govern disposal of wastes containing radioactive substances

4.7 Biological Characteristics

The removal of microorganisms, particularly human pathogens, from wastewater is an important consideration in land treatment. Microorganisms include bacteria, viruses and parasitic protozoa and helminths (worms). The residual concentration of microorganisms in treated wastewater is variable depending on several factors including type of wastewater, the efficiency and degree of disinfection, substrate concentration in wastewater, storage temperature and length of storage. The greater resistance of viruses to most disinfection procedures and the possibility of chlorination breakdown increases the importance of the ability of the soil to remove organisms.

Extensive field observations indicate that bacteria and viruses are removed from wastewater as it moves through the soil. Removal of microorganisms is accomplished by filtration and adsorption. Because of their large size, helminths and protozoa are removed primarily by filtration at the soil surface. Bacteria can be removed by filtration in the soil as well as by adsorption. Coliform removal in the soil profile has been shown to be approximately the same when primary or secondary pre-application treatment is provided. Unless fissures or dissolution channels are present for organism transport, soil will remove bacteria and viruses within several inches or few feet. Fecal coliforms are normally absent after wastewater percolates through five feet of soil. Viruses are removed primarily by adsorption.

After filtration and adsorption, the organisms then die due to radiation, desiccation, predation by other microorganisms and exposure to the adverse conditions in the soil. It is not expected that the presence of microorganisms in wastewater will be a limiting factor once wastewater has entered the soil, with the exception of animal grazing. See Section 6 for further discussion on grazing management.

To help minimize the exposure of receptors to microorganisms from land treatment system operations, land application methods should be conducted to minimize aerosol drift off site. Disinfection is required if human waste is treated and the fecal coliform concentrations exceed 200/100 ml. In addition, disinfection is required for wastewater applied to crops which are to be directly consumed by humans (see Section 6 for tables of microbial wastewater quality and buffer zone requirements, and IDAPA 58.01.17 for regulatory requirements. It is encouraged that crops which will be directly consumed by humans not be irrigated with wastewater.

Note: Phosphorus guidance revised as text, not a policy document, below

4.8 Phosphorus

The purpose of Section 4.8 is to provide the Idaho Department of Environmental (DEQ) permit writers with one approvable approach to dealing with protection of surface water from phosphorus when more specific information is not available.

Certain wastewater land treatment facilities, industrial facilities in particular, may generate appreciable quantities of phosphorus in wastewater streams. Many of these facilities have opted to land treat their wastewater. Since there are unique environmental considerations with respect to treatment of these wastewater streams, it is important to provide additional guidance to promote appropriate design, implementation and successful operation of these land treatment facilities.

4.8.1 Discussion

Phosphorus (P) is a required crop nutrient. It is also a major contributor of pollution to streams, causing algae blooms, low dissolved oxygen, undesirable plant growth, and fish kills. Phosphorus can reach streams by runoff from sites or inflow from aquifer recharge of the stream. Phosphorus has been implicated in the pollution of surface waters throughout the U.S., including Idaho. Phosphorus leaching from wastewater land application sites may present a risk of contamination to surface water depending on site-specific hydrologic conditions. In order to protect surface waters from the effects of excess phosphorus, surface runoff and deep percolation of phosphorus must be controlled. Surface runoff can contain significant amounts of dissolved and precipitated phosphorus. Phosphorus applied to the soil surface can be stored in the soil profile by precipitation and adsorption to soil particles. Eventually with significant P loading P can migrate to lower soil levels and even below the root zone. Once it goes beyond the root zone the P is unavailable for crop uptake and the coarser soil particles do not sorb significant quantities of P. Ground water will then begin to carry P from the site to other areas.

The concern for phosphorus contamination of surface water should be addressed in the development of wastewater land application permits. Applying runoff control technologies to limit surface runoff can prevent or mitigate environmental impacts related to surface runoff. Examples of these practices include applying water or wastewater at a rate less than the infiltration capacity of the soil, uniform sprinkler application, and using berms, ponds, and other runoff control structures. Controlling the application, soil accumulation, and leaching of phosphorus can prevent or mitigate impacts to surface water from ground water interconnections.

4.8.2 Guidance Recommendations

4.8.2.1 Phosphorus Guidelines

The Wastewater Land Application Permit Program recommends the following process to manage the risk of surface water being impaired by phosphorus applied to land application sites. This approach is designed to assure compliance with surface water quality standards for nutrients.

4.8.2.1.1 To address surface runoff concerns the following should be applied.

(1) The irrigation system must be designed such that no runoff of wastewater leaves the land application site or facility.
(2) Runoff controls and Best Management Practices (BMPs) should be established such that runoff of stormwater is only possible after storm events greater than the 25 year 24 hour storm event.
(3) Site closure plans should include consideration of accumulated phosphorus in the surface soils. Soil P upon completion of closure must not pose a threat to surface waters as a result of future irrigation practices or lack of adequate runoff control structures.

4.8.2.1.2 To address ground water interconnection with surface water the following approach is suggested

(1) Site-specific analysis, information, or other justification may be available that indicates that there is no ground water concern with respect to surface water. In the absence of this information the following goals should be considered for the ground water and the soil when preparing the WLAP permit.
    - Ground water concentrations at down-gradient compliance wells should be less than 0.1mg/l total phosphorus. However, if up gradient ground water is greater than 0.1 mg/l, no increase in total phosphorus should occur at down gradient compliance wells.
    - Achievement of any alternate goal, based on a ground water phosphorus allocation contained in a Total Maximum Daily Load (TMDL), should be attained.
    - Soil phosphorus values measured in the 24"-36" soil depth level should be less than the following.
        - 20 ppm P Olsen method[1] or 25 ppm Bray method[2] if ground water is less than 5 feet from the ground surface
        - 30 ppm P Olsen method or 50 ppm Bray method if ground water is greater than 5 feet from the ground surface

(2) If phosphorus levels exceed the goals established, then one of the following courses of action should be taken.

    - A permit holder may prepare a site-specific analysis that demonstrates an alternative limit or approach is protective of potentially impacted surface waters.

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[1] "Olsen" refers to the Olsen ($NaHCO_3$ extractant) method for determining plant available soil phosphorus. This method is applicable to calcareous soils with >2% CaCO3. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

[2] "Bray" refers to the Bray method for determining plant available soil phosphorus. This method is applicable to acid and neutral soils with < 2% CaCO3. See "Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters," Southern Cooperative Series Bulletin No. 396.

Upon approval by DEQ, this alternate limit or approach may be incorporated into the permit or otherwise used as appropriate.

- In the absence of any site-specific analysis and alternate limits or approaches approved by DEQ, a permit limitation for phosphorus loading should be considered at 100% of crop uptake.

4.8.2.2 Monitoring of Phosphorus

Soil monitoring for plant available phosphorus using the methods described in Section 3.1.2(2) appropriate for the soil type will normally be required. Soil sampling frequency and depth intervals to be sampled should be specified by DEQ in the WLAP permit.

Ground water monitoring for total phosphorus will normally be required. Frequency and locations for monitoring should be specified by DEQ in the WLAP permit.

4.8.2.3 Determining Compliance with WLAP Permit Phosphorus Limits

Standard WLAP permit templates for municipal sites include limits on the amount of phosphorus that can be applied to the land application site.

The WLAP permit limits are variable dependent upon site specific conditions:

Parameter	Permit Limit
Phosphorus	125% of typical crop uptake 125% of uptake values from standard tables; or Use of University of Idaho Fertility Guides

In order to determine compliance with 125% of typical crop uptake, for example, take the following steps:

1. Calculate the phosphorus uptake by the crop or crops harvested from each hydraulic management unit on the site for the three most recent years of data plant tissue data. Select the median value from these data and multiply by 1.5. This is the loading limit. (in pounds per acre)

To determine the permit limit for phosphorus using standard tables, find the crop type in Section 7.6. and look up the phosphorus content. Then multiply by crop yield (per acre) and by 1.5. This is the loading limit based on a standard table. If the crop grown at the site is not included in Section 7.6, contact DEQ to get nutrient uptake for the crop being grown or consult the following Idaho Department of Agriculture website: http://www.nass.usda.gov/id/publications/annual%20bulletin/annbulltoc.htm.

Note that the permit limit may change from year to year as the crop type changes or the crop yield changes.

2. Calculate the amount of nutrients applied by wastewater application or from other sources, such as supplemental fertilizers (in pounds per acre). To make this calculation, the following information is required:
   a. Volume of wastewater applied, gallons/year
   b. Wastewater quality in mg/l. Use total phosphorus
   c. The amount of supplemental phosphorus fertilizer applied or any other nutrient sources (pounds per acre)
   d. Calculate wastewater P loading from wastewater volume, concentration, and site acreage, and then sum wastewater and fertilizer loading rates to obtain total P loading.
3. Compare the permit limit calculated in Step 1 above to the amount of phosphorus applied calculated in Step 2 to determine compliance.

Example calculations are provided below.

4.8.2.4 Example Calculations

Example 1

Crop type: Alfalfa Hay
Crop yield: 4.5 tons/acre
Wastewater applied to land application field: 6 million gallons
Land application area: 20 acres
Wastewater total-phosphorus: 5 mg/l (ppm)
No supplemental fertilizer applied

1a. Calculate crop uptake of phosphorus
For alfalfa hay, the phosphorus uptake (from Table 7-26 Section 7) is 4.72 pounds per ton of yield.
Phosphorus uptake: 4.5 tons/acre x 4.72 pounds N/ton = 21.24 pounds/acre

1b. Calculate the phosphorus permit limits (125 % of crop uptake)
Phosphorus application-permit limit: 21.24 x 1.25 = 27 pounds/acre
(round off to nearest whole number)

2. Calculate the amount of phosphorus applied with the wastewater

Phosphorus: $\frac{6\ \text{MG}}{\text{year}} \times 5\ \text{mg/L N} \times \frac{8.34\ \text{pounds/MG}}{1\ \text{mg/L}} \times \frac{1}{20\ \text{acres}} = 12.5\ \frac{\text{lbs}}{\text{acre}}$

3. Compare phosphorus applied versus the permit limit to determine compliance

	Permit Limit 125% of crop uptake	Amount applied	In compliance with permit limit?
Phosphorus	27 pounds/acre	12.5 pounds/acre	Yes

Example 2

Crop type: Forest Site (pine tree)
Crop yield: Harvest per silvicultural plan
Wastewater applied to land application field: 14 million gallons
Land application area: 26 acres
Wastewater total-phosphorus: 4 mg/l (ppm)
No supplemental fertilizer applied

1a. Calculate crop uptake of phosphorus
From Table 7-26, Section 7, for tree sites, the phosphorus uptake allowance is 20 pounds per acre.

1b. Calculate the phosphorus permit limits (150% of crop uptake)
Phosphorus application permit limit: 20 x 1.25 = 25 pounds/acre
(round off to nearest whole number)

2. Calculate the amount of phosphorus applied with the wastewater
Phosphorus: $14\ \frac{\text{MG}}{\text{year}} \times 4\ \text{mg/L N} \times \frac{8.34\ \text{pounds/MG}}{1\ \text{mg/L}} \times \frac{1}{26\ \text{acres}} = 18\ \frac{\text{lbs}}{\text{acre}}$

3. Compare phosphorus applied versus the permit limit to determine compliance

	Permit Limit 125% of crop uptake	Amount applied	In compliance with permit limit?
Phosphorus	25 pounds/acre	18.0 pounds/acre	Yes

4.8.3 Reference

Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters. Southern Cooperative Series Bulletin No. 396.

4.9 Management of Total Dissolved Solids

Total Dissolved Solids (TDS) can be naturally occurring or man caused in ground water. Elevated levels of TDS are found in ground water in many areas of the state. Because of the need to protect ground water quality and sustain soil productivity WLAP facilities causing significant TDS impacts to ground water, or which pose a risk of causing significant impacts, should develop site specific TDS Management Plans. Plans should include, but not be limited to, the following:

a. identification of representative monitoring sites to measure TDS,

b. characterization of all known sources of inorganic TDS,
c. specification of alternatives to isolate and reduce TDS being generated or land applied,
d. evaluation of the expected improvements to ground water quality, and
e. e.an implementation schedule for TDS reduction

The approach described above is a passive remedial one and may not be appropriate for a facility that has or is currently impacting a ground water supply well. If a public water supply or a private water supply is contaminated by wastewater land treatment activities as described in IDAPA 58.01.11.400, actions on the part of DEQ and/or the facility may be indicated, also as described in Section 400.

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5. Not Used at This Time

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6. Operations

6.1 Pretreatment Considerations

The degree of pretreatment wastewater receives before land application can be a distinguishing factor in establishing site requirements. The necessary level of pretreatment can be site and/or wastewater specific. The main consideration is always whether the soil-crop system can treat the wastewater in question.

In some cases a change in the processing method could benefit the wastewater generator. If the process can significantly reduce the concentration of the land limiting constituent, increased loading of wastewater would be possible up to the point where the next land limiting constituent loading threshold is reached. Such processing changes would have to be evaluated as to their cost effectiveness (i.e., less land needed vs. cost of process change). However, more than one land limiting constituent may need to be reduced to allow higher loading rates.

6.1.1 Municipal Pretreatment

The primary concern regarding municipal wastewater treatment by land application is the potential health risk due to the presence of disease causing organisms. Most municipal wastewater will, therefore, require pretreatment that may include a considerable reduction of indicator organisms prior to land treatment. The degree of treatment will depend on the type and intended use of the crop, the method of wastewater application and extent of public access and exposure. Specific coliform treatment requirements for direct use of municipal wastewater are found in IDAPA 58.01.17.600.07.

Exceptions to the treatment requirements can be considered when it is demonstrated that the exception will not adversely impact protection of the public health and safety. This evaluation will include the participation of local health agencies and the affected public through their review and comment on the proposal. See Sections 4 and 6.6 for more information on this topic.

6.1.2 Industrial Pretreatment

Pretreatment requirements for industrial wastewaters will tend to be more variable than municipal wastewaters because there is often more diversity of critical wastewater constituents in these wastewater streams. Pretreatment will depend on its cost effectiveness in most cases. For example, additional treatment could reduce the land area needed to treat the wastewater. Metals, toxics, suspended solids, nitrogen and COD are examples of pollutants that may require additional treatment before the wastewater can be land-applied. Disinfection of industrial wastewaters is generally not required if it can be demonstrated that no sanitary sources of contamination exist and that the public health and safety will not be adversely affected.

6.2 Operation and Management Needs

6.3 Lagoons

This section discusses the purpose and need for wastewater storage structures at wastewater reuse facilities, design requirements, and seepage testing protocol.

6.3.1 Lagoons: Purpose and Need

Storage of wastewater is needed for some land treatment systems and other reuse systems. Wastewater generation and treatment plants can typically have one to several lagoons serving various purposes. The storage volume can vary from as little as one day's flow to as much as six months. Storage is needed when precipitation produces an excessive hydraulic load on the soil crop system; when cultivating practices prevent application; when winter weather conditions preclude operation; when flow variations in quantity and quality requires equalization; when winter weather forces a reduction in the rate of application; and as a backup for the treatment system under emergency situations. It is possible to reduce or remove storage requirements by providing alternative backup measures to be determined on a case-by-case basis.

The key elements to consider when determining storage requirements are the local climate and the period of operation. Storage is generally needed during the harsh winter months when application rates must be reduced. Evaluation of these elements helps to determine the needed storage volume. Analysis of rainfall data also helps identify the storage needs related to expected periods of excessive precipitation. Some storage may be necessary to retain certain storm events on the land treatment site to prevent runoff.

In some areas, and depending on wastewater characteristics, the winter weather may be mild enough to allow application during much of the winter. In these cases, consideration must be given to the trade-off of the cost of storage versus the cost of additional area for land application. See Section 4 for additional information on non-growing season application and storage practices. See also Section 6.8 for information on weed control around lagoons.

It is important for lagoons to be sufficiently sealed so that they do not become major contributors to the contamination of ground water. For this reason, members of the regulated community are required to demonstrate the integrity of their wastewater treatment and storage structures. The following provides guidance for methods to determine seepage rates for lagoon:

http://www.deq.state.id.us/water/assist_business/engineers/guidance/lagoon_seepage.pdf

Alternative methods may be submitted for review and approval DEQ.

6.3.2 Lagoons: Design Criteria

Design criteria for municipal and industrial lagoons are based on the *Ten State Standards* otherwise known as the *Recommended Standards for Wastewater Facilities – 2004* by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers pursuant to the *Idaho Water Quality Standards* (IDAPA 58.01.02.402). These design criteria for lagoons require lagoons be designed with a seal that has a seepage rate less than 500 gallons/acre-day (0.018 inches/day).

Performance criteria based on DEQ policy presently recommends lagoons be allowed to seep at a rate up to 3,400 gallons/acre-day (0.125 inches/day), or approximately seven times the design criteria. This rate is based on a perceived allowable error in physically measuring the seepage rate.

DEQ typically recommends that recent seepage data be submitted as part of the permit renewal application package each five years. Results of the seepage data will determine any permit conditions needed to update or modify existing lagoons.

If a properly tested lagoon leaks more than this 0.125 inches per day, the options for mitigation include 1) retesting the seepage rate immediately; 2) repair or replace or install liner and retest; or 3) develop a plan based on ground water sampling and analyses to determine the effect of the leakage on the local groundwater. If that impact does not comply with the *Ground Water Quality Rule*, then options 1 or 2 above remain.

6.4 Grazing Management

This section discusses grazing on wastewater land treatment sites, grazing plans, and special considerations regarding grazing on municipal land treatment sites.

6.4.1 General Discussion

Well managed livestock grazing is an effective method for harvesting crops grown on wastewater land treatment sites. Poorly managed livestock grazing on land treatment sites can result in negative environmental impacts and pathogen transmission to grazing animals if land applying municipal wastewater. For these reasons, the *Wastewater-Land Application Permit Regulations*, IDAPA 58.01.17.600.07 prohibits grazing on WLAP sites where municipal wastewater is applied. The intent of the regulations and the guidance is to discourage grazing altogether, as it may damage the site and the practice is difficult to regulate. However, DEQ does allow exceptions per some municipal sites as discussed in Section 6.4.3 below. DEQ allows grazing on non-municipal sites for fall clean-up of sites and growing season grazing, subject to certain conditions.

Livestock grazing management can avoid adverse impacts to the site and to the environment with careful consideration of: nutrient loading rates, compaction of the soil, damage to the irrigation system, and damage to the crop. Nutrient loading rates should be reduced (from those used for harvest sites) to match nutrient removal rates. For example, net nutrient removal should equal the crop nutrients consumed minus the nutrients deposited with the manure.

Soil compaction can cause decreased infiltration rates leading to increased potential for runoff and reduced plant growth. If animals are allowed on a land treatment site when soils are wet, substantial soil compaction can occur. This problem can be avoided by grazing when soil moisture is below field capacity.

Over-grazing of a site can decrease plant growth and vigor. Reduced plant growth decreases water and nutrient uptake, increasing the potential for deep percolation and contamination of ground water. Reduced plant vigor causes long term reduction in yields and the capacity of the site to support grazing. Over-grazing can be avoided by limiting the number of animals, limiting the time that animals remain on the field or plot, rotating livestock from plot-to-plot based on amount of remaining vegetation, and adhering to an approved grazing management plan.

6.4.2 Grazing Plans

A grazing management plan is required for any grazing occurring during the growing season. A grazing management plan is not required, but is recommended for a fall clean up operation. The purpose of a grazing management plan is to insure crop health and soil properties are maintained for effective wastewater land treatment. These plans should follow the guidance and specifications of relevant sections of the *USDA Natural Resource Conservation Service (NRCS) Field Office Technical Guidance* (FOTG). See the following Web site for the electronic FOTG (eFOTG):

http://www.nrcs.usda.gov/technical/efotg

Required grazing plans must be reviewed and approved by DEQ before being implemented. DEQ is also willing to review and approve non growing season grazing plans for fall clean up as time and resources allow, should facilities choose to write and submit a plan. One resource for developing grazing plans is the NRCS. Table 6-1 lists several practice names and codes from the FOTG whose specifications are relevant to grazing.

Table 6-1. Relevant FOTG Approved Grazing Specifications

Practice Name	Code	Where Applicable
Pasture and Hayland Management	510	Pasture land and hayland
Pasture and Hayland Planting	512	Pasture, hayland, or land converted from other uses
Grazing Land Mechanical Treatment	548	Native grazing land
Planned Grazing Systems	556	Range, pasture, hayland, woodland, wildlife land
Proper Grazing Use	528	Range, native pasture, grazed wildlife land
Proper Woodland Grazing	530	Wooded areas

USDA SCS FOTG, 1986

6.4.2.1 Conditions for all WLAP Grazing

All WLAP site grazing is subject to the following conditions:

- Livestock should be on site only until feed is reasonably depleted; minimum leaf heights and stubble heights before and during grazing should be observed. (see Table 6-2, from Soil Conservation Service Idaho Field Office Technical Guide Pasture and Hayland Management 510-6, Table 1, September 1986.)
- There should be no irrigation while livestock are on site.
- Livestock should be removed if precipitation wets soil such that soil/crop damage may result. (see soil moisture determination).
- 4A written statement is needed by DEQ from the permittee stating that the permittee has control over the management of the grazing animals.
- There should be no supplemental feeding of livestock while on the WLAP site, unless DEQ approves such feeding in writing.

Table 6-2. Growth Stage for Harvesting Forage

Column A Plant Species - Common Name	**Co1umn B** Minimum Leaf Length Reached Prior To InitIating Grazing (in.)	**Column C 1/** Minimum Stubble Height to Remain. Following Grazing Or Hay Harvesting (in.)
Kentucky bluegrass	6	3
Smooth bromegrass	8	4
Regar bromegrass	8	4
Reed canarygrass	10	6
Tall fescue	8	4
Orchardgrass	8	4
Timothy	8	4
Garrison creeping foxtail	10	4
Tall wheatgrass	10	8
Intermediate wheatgrass	10	4
Pubescent wheatgrass	8	4
Siberian wheatgrass	6	3
Crested wheatgrass	6	3
Russian wildrye	8	4
Alfalfa	14	3
Ladino clover	8	3
Red clover	6	3
Alsike clover	6	3
Sweet clover	8	4
Trefoil	8	3
Sainfoin	12	6
Milkvetch	8	4
White dutch clover	4	2

1/ This is the minimum stubble height to be remaining at end of grazing period or hay harvest operation. When a grass-legume mixture is harvested for hay, generally use most limiting stubble height for the mixture.

In the event there is a significant precipitation event (standing water or muddy conditions are signs) while livestock are on the site, a determination of soil moisture should be made to assess whether crop damage and/or soil compaction will result. Soils can be sampled after the precipitation event and evaluated for soil moisture according to Table 6-3.

“The feel method involves collecting soil samples in the root zone with a soil probe or spade. Then, the water deficit for each sample is estimated by feeling the soil and judging the soil moisture as outlined in …” the table below. “Soil samples should be taken at several depths in the root zone at several places in the field.” (Taken from Wright and Bergsrud, 1991).

Table 6-3. Guide For Judging Soil Water Deficit Based on Soil Free and Appearance for Several Soil Textures (Wright and Bergsrud, 1991)

SOIL TEXTURE CLASSIFICATION

Moisture deficiency **in/ft**	*Coarse* *(loamy sand)*	*Sandy* *(sandy loam)*	*Medium* *(loam)*	*Fine* *(clay loam)*	*Moisture deficiency* **in/ft**
.0	*(field capacity) Leaves wet outline on hand when squeezed*	*(field capacity) Appears very dark, leaves wet outline on hand, makes a short ribbon.*	*(field capacity) Appears very dark, leaves wet outline on hand, will ribbon out about one inch.*	*(field capacity) Appears very dark, leaves slight moisture on hands, when squeezed, will ribbon out about two inches.*	**.0**
.2	*Appears moist, makes a weak ball*				**.2**
.4	*Appears slightly moist, sticks together slightly.*	*Quite dark color, makes a hard ball.*	*Dark color, forms a plastic ball, slicks when rubbed.*	*Dark color, will slick and ribbons easily.*	**.4**
.6	*Appears to be dry, will not form a ball under pressure.*	*Fairly dark color, makes a good ball.*	*Quite dark, forms a hard ball.*	*Quite dark, will make thick ribbon, may slick when rubbed.*	**.6**
.8		*Slightly dark color, makes a weak ball.*	*Fairly dark, forms a good ball.*	*Fairly dark, makes a good ball.*	**.8**
1.0	*Dry, loose, single-grained flows through fingers. (wilting point)*	*Lightly colored by moisture, will not ball.*	*Slightly dark, forms weak ball.*	*Will ball, small clods will flatten out rather than crumble.*	**1.0**
1.2		*Very slight color due to moisture, loose, flows through fingers. (wilting point)*	*Lightly colored, small clods crumble fairly easily.*		**1.2**
1.4			*Slight color due to moisture, powdery, dry, sometimes slightly crusted but easily broken down in powdery condition. (wilting point)*	*Slightly dark, clods, crumble.*	**1.4**
1.6				*Some darkness due to un-available moisture, hard baked, cracked sometimes has loose crumbs on surface. (wilting point)*	**1.6**
1.8					**1.8**
2.0					**2.0**

Table 6-4. Generalized Drainage Times for Uniform Soil Profiles of Varying Textures

Texture	Drainage Time (Range in days)
Loamy Sand	0.5 - 2
Sandy Loam	3 - 4
Silt Loam	4 - 6
Clay Loam	5 - 7

Carlisle and Phillips, 1976 and Donahue et al., 1977

6.4.2.2 Conditions for Growing Season Grazing

When developing a grazing management plan specifically for the growing season, the following items should be included:

- Specify the type and number of animals to be grazed on the site.
- Identify when animals can be put on a plot and when they should be taken off based on plant growth characteristics (plant height or other criteria). Indicate the primary growing season or months anticipated for the grazing season.
- Provide a schedule for rotating the animals through the site. Include a map showing plot arrangement, location of salt blocks, protein blocks, and water. The grazing management plan should include a schedule for rotating the location of any salt or protein blocks to prevent excessive traffic on any portion of the site.
- Work out a nutrient balance, which accounts for crops grown, yield, nutrients removed and added by livestock.

6.4.2.3 Conditions for Fall "Clean-Up" (Non-Growing Season)

If a WLAP site is to be grazed solely for the purpose of fall "clean-up" of the site, then the following conditions should be met:

- Livestock should be on site only after harvest.
- Livestock should be off site no later than December 31st.
- No winter pasturing of livestock, or supplemental feeding.

6.4.3 Grazing on Land Application Sites Irrigated with Treated Municipal Wastewater

This section establishes program guidance on the practice of using treated municipal wastewater to irrigate sites grazed by animals used for dairy or meat production. The Idaho State Department of Agriculture (ISDA) and the Idaho Division of Environmental Quality (DEQ) jointly developed this guidance.

In February 1990, Idaho DEQ established program guidance to disallow grazing on all land application sites using treated municipal wastewater. The primary reasons cited for this decision were 1) the potential public health risks and 2) the limited resources of the agency to reasonably insure compliance with grazing management plans.

Recently, several municipalities have inquired if grazing animals on new land application sites would be acceptable. EPA guidance (1992) and recent regulations developed by neighboring States indicate grazing is acceptable under certain conditions. Therefore, DEQ drafted a recommendation for grazing municipal sites and sought comments from ISDA and the District Health Departments. ISDA indicated they had several animal health concerns in regards to the draft guidance.

ISDA and DEQ formed a working committee to revise the draft guidance to address potential health risks, to both humans and grazing animals. Guidance provided in Table 6-5 is the mutual recommendation of ISDA and DEQ.

Table 6-5. Grazing on Municipal Wastewater-Land Applications Sites

Category	Type of Wastewater	Grazing allowed on land application site?
I	Municipal wastewater that is oxidized, coagulated, clarified, filtered, or treated by an equivalent process and disinfected to 2.2 total coliform organisms per 100 ml [1]	yes [2, 3]
II	Municipal wastewater that is oxidized and disinfected to 2.2 total coliform organisms per 100 ml [1]	Dependent on analysis of specific proposal [2, 3, 5]
III	Municipal wastewater that is oxidized and disinfected to 23 total coliform organisms per 100 ml [1]	Dependent on analysis of specific proposal [2, 4, 5]
IV	Municipal wastewater that is oxidized and disinfected to 230 total coliform organisms per 100 ml [1]	no
V	Municipal wastewater that is oxidized, no disinfection	no

1. Median total coliform count is based on bacteriological results of the last 7 dates for which analyses have been completed. A minimum chlorine residual of 0.5 mg/l is recommended in the applied wastewater for systems using chlorine to disinfect. Following disinfection, no further wastewater input allowed (piped distribution).
2. DEQ approved grazing management plan required. See Section 6.4.2 for information on grazing management plans.
3. For Categories I and II, a minimum waiting period of 0.5 to 7 days prior to grazing pasture irrigated with wastewater is required to allow for soil drainage and pathogen die-off. Generalized drainage times for various soils are given in Table 6-4 above.
4. For Category III, the recommended minimum waiting period prior to grazing is 15 to 30 days depending on soils, drainage times and pathogen die-off. See also Table 6-4 for generalized drainage times.
5. All odor provisions are also applicable. See Section 2.4.2 for further discussion of odor and other nuisance conditions.

6.4.4 References

Carlisle, B. L., and J. A.Phillips, June 1976. Evaluation of Soil Systems for Land Disposal of Industrial and Municipal Effluents. Dept. of soil Science, North Carolina State University.

Donahue R. L., R. W. Miller, and F. C. Shickluna., 1977. Soils – An Introduction to Soils and Plant Growth (4th Edition). Prentice Hall, 626 pages.

USDA Natural Resource Conservation Service. Field Office Technical Guides (FOTG). See the following web site for the the electronic FOTG (eFOTG) (http://www.nrcs.usda.gov/technical/efotg)

Wright, Jerry, and Fred Bergsrud. 1991. Irrigation Scheduling. Minnesota Extension Service publication no. AG-EO-1322-C.

6.5 Buffer Zones

Buffer zones provide distance between the boundary where wastewater-land application ceases and dwellings, public or private water supplies, surface water, or areas of public access.

Buffer distances are established to protect 1) the public from unnecessary exposure to land applied wastewater, and 2) drinking water supplies and surface water.

This section presents general buffer zone guidance, and more specific guidance applicable to municipal and industrial wastewater land treatment facilities. Also presented are criteria for alternative industrial wastewater buffer zone distances.

6.5.1 General Buffer Zone Distances

The following are general recommendations for buffer zones from wastewater land treatment sites to various land use features. These distances should be considered to protect against the potential for aesthetic and public health impacts.

- A land treatment system should not be located closer than 300 feet from the nearest inhabited dwelling.
- A land treatment system should not be located closer than 1,000 feet from a public water supply well or 500 feet from a private water supply well used for human consumption.
- A minimum of 50 feet should be provided between the wastewater application site and areas accessible by the public.
- The distance from permanent or intermittent surface water other than irrigation ditches and canals from the treatment site should be 100 feet.
- A 50 foot separation distance should be provided between the land treatment site and temporary surface water and irrigation ditches and canals.

- A map should be prepared and submitted to DEQ indicating the location of the land treatment system and the location of all wells, wetlands, streams, canals, and lakes within 1/4 mile of the treatment site.

6.5.2 Municipal Wastewater Buffer Zones

Expanded guidance for municipal wastewater is found in Table 6-6. There are sixteen different scenarios, scenarios A through P, which can be used for existing and new land application systems. To use the table, read vertically, factoring in the appropriate conditions. For example, Scenario D uses a municipal wastewater with effluent of advanced secondary quality; the WLAP site is in a residential area; and the wastewater is sprinkle irrigated. Continuing down the column, buffer zones and posting requirements are given.

Table 6-6. Municipal Wastewater Buffer Zone Treatment Sites

SITE CONDITION	SCENARIOS															
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
DEGREE OF TREATMENT																
Primary Undisinfected with org TNTC (1)	X				X				X				X			
Primary Disinfected to 230 org/100 ml (1)		X				X				X				X		
Secondary Disinfected to <23 org/100 ml(1)			X				X				X				X	
Advanced Secondary Disinfected to <2.2 org/100 ml (1)				X				X				X				X
LOCATION:																
Suburban or Residential Area	X	X	X	X					X	X	X	X				
Rural or Industrial Area					X	X	X	X					X	X	X	X
MODE OF IRRIGATION																
Sprinkler Irrigated	X	X	X	X	X	X	X	X								
Furrow Irrigated									X	X	X	X	X	X	X	X
RESULTING BUFFER ZONE REQUIREMENTS:																
BUFFER ZONE BETWEEN:																
Site and Inhabited Dwellings	1000 ft	1000 ft	300 ft	100 ft	1000 ft	1000 ft	300 ft	100 ft	300 ft	300 ft	50 ft	50 ft	300 ft	300 ft	50 ft	50 ft
Site and Areas Accessible to Public	1000 ft	500 ft	50 ft	0 ft	1000 ft	300 ft	0 ft	0 ft	100 ft	100 ft	0 ft	0 ft	50 ft	50 ft	0 ft	0 ft
FENCING TYPE																
Cyclone w/Barbed Wire									X	X						
Woven Pasture Fence	X	X	X		X						X		X	X		
Three-Wire Pasture Fence						X	X									
None Required				X				X				X			X	X
POSTING																
Required (2)	X	X			X	X			X	X			X	X		
Required (3)			X	X			X	X			X	X			X	X

(1) Bacteria count represents the total coliform bacteria as a median of the last 7 days of bacteriological sampling for which analysis have been completed
(2) Signs should read 'Sewage Effluent Application - Keep Out' or equivalent to be posted every 500 feet and at each corner of the outer perimeter of the buffer zone(s) of the site
(3) Signs should read 'Irrigated with Reclaimed Wastewater - Do Not Drink' or equivalent to be posted every 500 feet and at each corner of the outer perimeter of the buffer zone(s) of the site

6.5.3 Industrial Wastewater Buffer Zones

Buffer zones for industrial wastewater apply to both existing land application systems and to all new systems to protect public health and prevent aesthetic impacts or public nuisance conditions (Table 6-7). The 300 foot and 50 foot buffer zones are used as typical distances for industrial wastewater(s). To use the table, read vertically, factoring in appropriate site or facility conditions.

Table 6-7. Industrial Buffer Zone Scenarios.

SITE CONDITION FOR INDUSTRIAL WASTEWATER	SCENARIOS			
	A	B	C	D
LOCATION				
Suburban or Residential Area	X	X		
Rural or Industrial Area			X	X
MODE OF IRRIGATION				
Sprinkler Irrigated	X		X	
Furrow Irrigated		X		X
RESULTING BUFFER ZONE REQUIREMENTS:				
BUFFER ZONE BETWEEN:				
Site and Dwellings	300 ft	300 ft	300 ft	300 ft
Site and Areas access. to Public	50 ft	50 ft	50 ft	0 ft
FENCING TYPE				
Three-Wire Pasture Fence	X	X		
Not Required			X	X
POSTING				
Required (1)	X	X		
Not Required			X	X

(1) Signs should read 'Irrigated with Reclaimed Wastewater - Do Not Drink' or equivalent to be posted every 500 feet and at each corner of the outer perimeter of the buffer zone(s) of the site.

There may be instances when the buffer zones are overly protective for a particular facility or site and if so, then the permittee may use the prescribed criteria that follows in Section 6.5.4 to propose alternative buffer zones. Likewise, DEQ may require greater distances for buffer zones, for example, if the wastewater is of the same quality as raw or primary sewage. Applicants are encouraged to provide justification alternative buffer zones prior to system design. All buffer zones must comply with, local zoning ordinances.

6.5.4 Criteria for Alternative Wastewater Buffer Zones

If a buffer zone is considered unreasonable or unnecessary for a specific site, it is incumbent upon the permittee to propose an alternative distance and justify this proposal to DEQ. The alternative distance proposal should be specific to a given site and should demonstrate how public health and the waters of the state will be adequately protected. Additional information to consider when proposing an alternative buffer zone may include but is not limited to the items listed below:

- Provide a higher degree of pretreatment for wastewater, such as oxidation, anaerobic treatment, disinfection or filtration, prior to applying to land surface.
- Show how alternative methods of irrigation such as low pressure sprinkler irrigation will reduce spray or air borne exposure from drift[3].
- Provide a physical or vegetative barrier that has been adequately designed to reduce drift or aerosol[1] dispersion. A vegetative barrier should provide adequate buffer capability for the seasons the wastewater is being applied. See Spendlove, et al., (1979/1980), for one example of how to design vegetative barriers.
- Determine the wind speed and direction on a site specific basis to verify when spraying by pressure irrigation can take place.
- Conduct a pathogen study of wastewater showing levels of pathogens under typical operating conditions.
- Demonstrate how using either best practical methods, approved best management practices or best available technology can effectively minimize impacts to public health and waters of the state.

Alternative wastewater buffer zone proposals submitted by the permittee may include from one to all six items listed above depending upon what is necessary. The above list is not intended to denote any particular ranking or prioritization of items but rather is intended to present a number of possible options.

6.5.5 References

Kincaid, D. 1995. Personal communication from Kincaid to DEQ in 1995

Spendlove, J. C., R. Anderson, S. J. Sedita, P. O'Brian, B. M. Sawyer and C. Lue-Hing. 1979/1980. Effectiveness of Aerosol Suppression by Vegetative Barriers. *in* Wastewater Aerosols and Disease, EPA 600/9-80-028, Cincinnati, Ohio, H. Pahren and W. Jakubowski, editors 1979/1980

6.6 Protection of Domestic and Public Well Water Supplies

This section discusses regulatory programs which serve to protect well water supplies. Also discussed is well water supply protection for those wells in the vicinity of wastewater land treatment facilities.

[3] Drift is typically considered to be those droplets greater than 200 microns in size and aerosol is generally considered to be droplets less than 200 microns in size (Kincaid, 1995, ARS, Kimberly, Idaho.)

6.6.1 Wellhead Protection Areas

The Amendments to the *Safe Drinking Water Act* of 1986 authorized the Wellhead Protection Program for states to develop and implement for protection of ground water and drinking water supply systems. The Wellhead Protection Program is intended to supplement the existing drinking water rules and drinking water standards. As such, local communities can use the state Wellhead Protection Program as the minimum criteria upon which they can design their own protection program based on local conditions. Idaho's Wellhead Protection Program is using a voluntary approach so that while implementing a local Wellhead Protection Program is encouraged, it is not mandatory. DEQ is designated to provide technical assistance and guidance on the Wellhead Protection Program to local governments and water system purveyors.

Since each community can choose to develop a Wellhead Protection Plan as additional protection beyond what is required by the Rules Governing Drinking Water, it is recommended that a WLAP permittee contact either their city/county government or water purveyor if uncertain on established or developing local wellhead protection programs. Such wellhead or wellfield protection areas may be more restrictive than the wellhead setback distances discussed below (Section 6.6.3) and in Section 6.5 above. Refer to Section 15.14. **below** for special considerations on wellhead protection areas and wastewater land treatment systems overlying the Rathdrum Prairie Aquifer. A copy of the Idaho Wellhead Protection Plan (DEQ, 1997) may be requested from DEQ.

The site specific questions pertaining to the siting of wells and wastewater land treatment sites with respect to each other are many and are discussed in more detail below. Before discussion of physical site specific factors, it must be noted that local zoning considerations are perhaps one of the major concerns with designating wellhead protection areas. *It is the responsibility of the WLAP permittee or applicant to inquire of appropriate planning and zoning jurisdictions and local governing bodies whether their site is within a wellhead protection area*. If so, local ordinances and planning and zoning requirements are to be taken into account and, where stricter than state regulations, are to be used in the design of the facility and in the siting of wells and treatment sites.

6.6.2 Domestic Water Supplies

A permit to construct a well is required by the Rules and Regulations, Well Construction Standards (IDAPA 37.03.09) administered by the Idaho Department of Water Resources. This permit applies to all water wells including domestic wells (individual, public, and non-public wells), irrigation wells, monitoring wells, and low temperature geothermal wells. The same permitting requirements apply to wells that are drilled to augment or replace existing wells.

Placement of wells in relation to potential sources of contamination, such as wastewater-land application systems, is addressed by DEQ or the District Health Department, depending on the source of contamination and/or the land use activity.

If the well supplies a public drinking water system (see the Drinking Water Rules, IDAPA 58.01.08), then maintaining the structural integrity of the distribution system and determining the quality of water in the system comes under the jurisdiction of DEQ for a system with 25 or more connections, or serving 25 or more individuals. Wells come under the jurisdiction of the local District Health Department if supplying a public water supply system with 15 through 24 connections, non public water supply systems with 2-14 connections or an individual domestic well.

6.6.3 Protection of Well Water Supplies Near Wastewater Land Treatment Facilities

Section 6.5 above recommends buffer zones of 500 feet between domestic wells and a wastewater land treatment site and 1000 feet between the latter and a municipal water supply well. Applicants may choose to use these recommended distances, or they may choose to evaluate respective locations of wastewater land treatment sites and wells using the well location acceptability analysis. Known water quality problems associated with an area or existing site may preclude the use of the distances provided in Section 6.5 above.

The discussion that follows on Well Location Acceptability Analysis, considers the hydrogeological setting, well construction; and the management, operation, and loading of the land treatment site to determine suitability of respective locations of water supply wells and land treatment acreage. This guidance may also be used to determine location suitability of irrigation wells and injection wells; not to protect a supply of water yielded for consumption by these wells, but rather to prevent the irrigation or injection well from acting as a conduit allowing the land applied wastewater to reach the aquifer.

The sections below describe Well Location Acceptability Analysis protocol. Also discussed are descriptions and methods to conduct capture and mixing zone analyses.

6.6.3.1 Well Location Acceptability Analysis

Figure 6-1 is a decision flow chart, which provides guidance on the acceptability of domestic private, shared (non-public) or municipal (public) well locations with respect to wastewater land treatment sites and the potential adverse impacts the latter may have on potable water supplies. Generally, whenever a location for a well is termed acceptable, this means the wastewater land treatment site is not causing contamination of the aquifer and the beneficial uses of the ground water pumped from the well are maintained. The wastewater-land application permit may require monitoring of said well to substantiate that contamination is not occurring at present or in the future. When Figure 5 states "Well Site Location Not Acceptable" it means that the relative positions separating the planned or actual wastewater land treatment site and an existing or planned well is unacceptable.

The first question in the flow diagram asks whether the well is closer than 1/4 mile from the site. This question establishes an initial universe of wells to consider the suitability of the wastewater-land application site in relationship to wells. If the well is not within 1/4 mile, it is generally not considered, but can be, depending on site specific conditions.

If a well is closer than 50 feet from the wastewater land treatment site, the location is not acceptable, according to the *Rules Governing Drinking Water*, IDAPA 58.01.08.550.02a. The same protection is provided for all domestic water systems whether an individual, non public or public water supply system. Based on required distances in the drinking water regulations for other types of sewage systems (IDAPA 58.01.08.900.01), a 100 foot separation distance is considered an appropriate separation distance between a well and a municipal wastewater-land application site. In the event the wastewater land treatment site is not applying municipal wastewater or the well is farther than 100 feet, then questions regarding the nature of the aquifer follow.

If the well is completed in a confined aquifer, and both the integrity of the confining layer(s) and well construction are documented, then generally the location is acceptable. If the well is not completed in a confined aquifer, or is not adequately constructed in the same, or if the nature of the confining layer is not documented, the well is regarded to be in a shallow water table aquifer.

The next question asks whether the wastewater land treatment site is an existing one or not. If it is not an existing site, but a proposed site, then a Capture Zone Analysis (CZA) is done where time (t) = 5 years. A capture zone analysis is done to see if the boundaries of a wastewater-land application site overlie~~s~~ the delineated zone from which the well draws water. A capture zone, or zone of contribution as it is sometimes called, is defined as the area surrounding a pumping well that supplies ground water recharge to the well (EPA 1991) (see further discussion below in Section 6.6.3.2.

The question which follows asks whether the wastewater land treatment site lies within the five year capture zone. If it does not, the well wastewater land treatment site location is acceptable for the five year life of the permit. The reasoning being that if the proposed site is predicted to cause ground water contamination, or actually does cause contamination, that the well would be safe from those impacts for five years.

EDITOR'S NOTE: But after 5 years, the contamination plume generated from the site would intercept the well. The well would show contamination during the time that the plume passes the well. If the facility changes operations and loading rates to halt continued contamination, there will be a lag time measured in years before the well water quality would again reflect non-contaminated conditions. If the facility does not change operations, the well will likely continue to be contaminated. The left leg of the Figure 5 flow chart should be deleted, and there should be no question regarding, nor distinction made between, existing or proposed sites.

If the wastewater land treatment site lies within the five year capture zone, and municipal wastewater is applied, the well/site location is not acceptable. A five year travel time has been set as a protective minimum for attenuation of pathogens potentially introduced into the aquifer from wastewater land treatment sites.

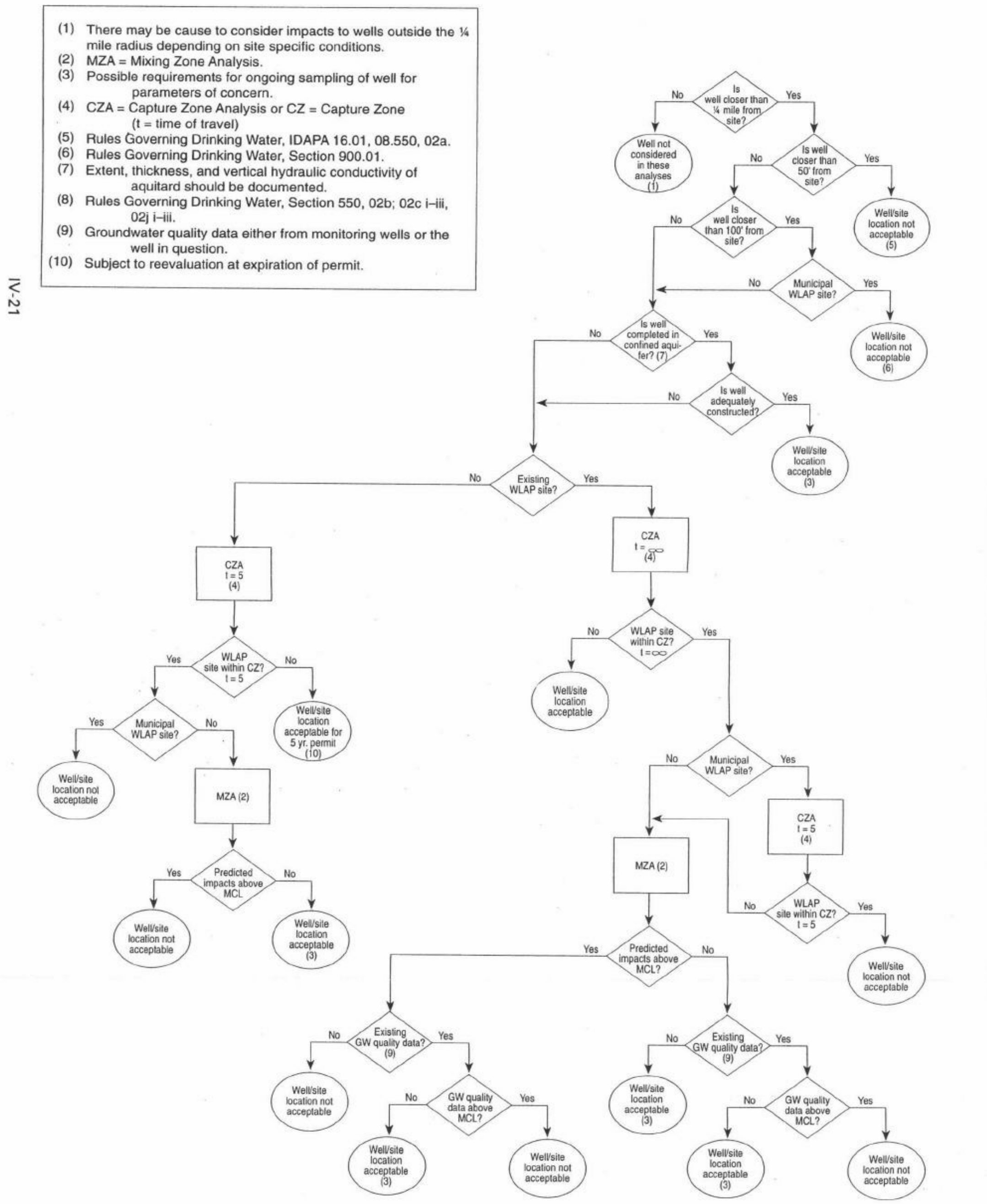

Figure 6-1. Well Location Acceptability Analysis.

If the site is not a municipal site, and yet is within the five year capture zone, a mixing zone analysis (MZA) is done to determine whether predicted impacts from the wastewater land treatment site exceed water quality standards or compromise beneficial uses of the ground water.

The standards are expressed as maximum contaminant levels (MCLs) in DEQ's Ground Water Rule (IDAPA 58.01.17.200).

The mixing zone analysis equation referenced in the decision flow chart is taken from EPA (1981) as mentioned previously. Other mixing zone analysis models may be used if accompanied by appropriate justification and/or documentation.

If predicted impacts from the MZA yield results above MCL, the well/site location is unacceptable. If the predicted impacts from the MZA yield results below MCL, the well/site location is acceptable.

In the event the wastewater land treatment site is an existing one, a CZA is done where time (t) = infinity. Time (t) = infinity since the land application system may have been in operation anywhere up to 15 years and as such, is presumed that ground water impacts may have occurred. This step in the flow chart is showing an existing site that potentially has impacted ground water, as compared to a new or proposed site as discussed above, where there is generally no pre-existing ground water impacts from wastewater land treatment. Also, while a five year lag time is used after initiating use of a new site, this same lag time is not appropriate for an existing site, because of the uncertainty of how far a contamination plume may have moved in the ground water since the existing WLAP operation began.

The well wastewater land treatment site location analysis is more protective for existing sites than for new sites. A capture zone analysis where time (t) = infinity yields a zone where every flow line to the well possible is included. Every flow line should be considered since the conservative assumption is made that predicted down gradient steady-state constituent concentrations have the potential to affect the ground water at the wellhead.

The next question asks whether the well is within the capture zone. If it is not, the well/site location is acceptable, as the well will probably not be drawing from a zone influenced by WLAP land-use practices. If the well is within the capture zone, the next question asks whether the wastewater land treatment site is a municipal site. If so, a CZA is done where t = 5 years. If the wastewater land treatment site is within the five year capture zone, the well/site location is not acceptable for reasons mentioned above.

If the well is not within the five year capture zone, an MZA is done to determine whether predicted impacts from the wastewater land treatment site exceed primary and secondary maximum contaminant levels (MCLs) in DEQ's Ground Water Rule (IDAPA 58.01.17.200) (See Section 6.6.3.3 for additional information on the MZA), and so compromise the potable water supply beneficial use.

In the event predicted impacts from the MZA yield results above MCL, the applicant may provide ground water quality data to demonstrate no exceedance of MCLs at the well. The well/site location is not acceptable if there is no ground water quality data substantiating no impacts above MCL. However, in the event there is existing ground water quality data showing levels below MCL, then the well/location is generally acceptable with possible monitoring conditions. If monitoring data show levels higher than MCL, the well/site location is not acceptable.

Should the predicted impacts not exceed MCLs and there is no ground water quality data (either from site monitoring wells or from the well in question), or there is ground water quality data showing levels below MCL, then the location of the well is acceptable. In the event there is ground water data and it shows impacts above MCL, then the well/site location is not acceptable.

6.6.3.2 Capture Zone Analysis

A capture zone, or zone of contribution as it is sometimes called, is defined as the zone surrounding a pumping well that will supply ground water recharge to the well (EPA 1991). Capture zone analyses are done to see whether the delineated zone where a well draws water overlies the boundaries of a wastewater-land application treatment area. Such a well is subject to potential impacts from this land-use activity. A calculation methodology for determining time of travel boundaries is given below. Also discussed are computer models which perform these calculations, and sources of input parameters for modeling software.

6.6.3.2.1 Determination of Basic I Time of Travel Boundaries

The radii calculations (calculated distances outward from the well representing time of travel boundaries) are based on advective transport and have taken into consideration the velocity of ground water around pumping wells and the velocity of the natural regional ground water flow. The calculated distance is in an upgradient direction from the well and combines these two components.

The derivation of the velocity of ground water flow around pumping wells is an additive process of the average linear velocity equation and the Theis equation for the radial component. The average linear velocity is a velocity representing the rate at which water moves through the interconnected pore spaces. The Theis equation predicts the drawdown in hydraulic head in a confined aquifer at any distance “r” from a well at any time “t” after the start of pumping if the aquifer properties of transmissivity (T), storativity (S), and pumping rate (Q) are known. The Theis equation assumes the hydraulic properties of the aquifer are uniform throughout the area of interest. These two equations are given below.

1) Average linear velocity equation:

$v = (K/n_e)(dh\cancel{s}/dl\cancel{r})$

where,

K = hydraulic conductivity, in gallons per day per ft^2 (gpd/ft^2)

n_e = effective porosity

(dh/dl) = hydraulic gradient through the well in an up gradient direction (change in head, h, over a given distance, l)

2) Theis equation:

$s = (Q/4\pi T) \int e^{-u}/u)du$, where $u = (r^2S/4Tt)$ and $(du/dr) = (2rS/4Tt)$

If the Theis equation is expanded and differentiated with respect to “r” from u to infinity, the factor, (ds/dr), can be substituted into the linear velocity equation to simplify the equation to:

$v = (K/ n_e)(Q/2\pi Tr)\, e^{(r2S/4Tt)}$

where,

Q = flow rate in gallons per day (gpd)

T = transmissivity in gallons per day per ft (gpd/ft)

r = distance between observation point and well in feet

S = storativity

s = drawdown in feet

t = time in days

As the drawdown approaches equilibrium, i.e. when “t” is very large, $e^{(r2S/4Tt)}$ will approximate 1, so the velocity equation can be simplified to:

$v = (K/ n_e)(Q/2\pi Tr)$

The equation used to calculate the radius plus the distance that accounts for regional flow up gradient of the well (including the conversion factor of 1 ft^3/day = 7.48 gal/day) is:

$\text{Distance} =(K/(7.48 \times n_e))(ds/dr) + (K/(7.48 \times n_e)) (Q/2\pi Tr)$

6.6.3.2.2 Capture Zone Modeling Software

The Wellhead Protection Area (WHPA) software may be used to define these capture zones, which is a modular semi-analytical model developed by EPA-(1991)

WHPA computes the distance from a wellhead that a particle would need to be in order to arrive at the wellhead in up to ten (10) years. The calculation assumes:

- that the well has been pumping at the specified flow rate for a very long time such that an equilibrium velocity is established;
- a straight line from the point of origin of the parcel and the well; and
- that the groundwater flow is in the direction of the parcel flow.

Calculated radii, utilizing the methodology above, for the various hydrogeologic settings and different pumping rates are given in Tables 4.8a- e in DEQ (1997). The results of the calculations for the 2 year and the 5 year time of travel wellhead protection areas were spot checked with results calculated from the WHPA Code 2.0. The calculations for the 2 year and the 5 year wellhead protection areas are comparable (See DEQ, 1997, Figures F-1 through F-4, which show both numerical results and plot graphs of time of travel boundaries). This software, however, has been superceeded by WhAEM 2000 (EPA, 2000).

6.6.3.2.3 Sources of Input parameters

General input values for capture zone models can be found in DEQ's Idaho Wellhead Protection Plan (DEQ 1997) among other sources. Several important model input sources are appended. Figure 2-1 shows locations and types of major aquifers in Idaho. The appendix contains a general table of aquifer properties, an extended table of transmissivities (and other data) for several wells in Idaho, a table of hydraulic conductivities, a map of hydraulic conductivity zones, and, from Freeze and Cherry (1979) hydraulic conductivities for typical aquifer materials. The latter four provide general parameter values for input to the capture zone model mentioned above. Each site should use values as site specific as possible for input to the model. The appendix also has a series of figures showing example capture zone delineations for major aquifers in Idaho, including mixed volcanic and sedimentary rocks, primary sedimentary rocks, unconsolidated alluvium, Colombia River basalts, and East Snake River Plain basalts.

6.6.3.3 Mixing Zone Analyses Ground Water Impact Limitations from Wastewater-Land Application

The calculations described below provide estimates of potential ground water constituent concentrations resulting from the operation of a WLAP system: 1) after the system has reached steady state conditions; and 2) under ongoing consistent management of the system. These constituent concentrations should not exceed current primary and secondary maximum contaminant levels (MCLs and SMCLs).

One mixing zone analysis equation used to predict steady state ground water quality is found in EPA (1981). It provides a rough estimate of the potential of the site, as managed or as proposed to be managed, to impact ground water moving beneath the site.

The following formula from EPA (1981) may be used:

$$Cmix = \frac{Cp*Qp + Cgw*Qgw}{Qp + Qgw}$$

Where:

Cmix = *steady state ground water concentrations down gradient of (after) mixing percolate and ambient ground water. (mass/volume).*
Cp = *concentration of constituent in percolate(mass/volume).*
Qp = *flow of percolate (volume/time)*
Cgw = *ambient upgradient concentration of constituent (mass/volume).*
Qgw = *flow of ground water (volume/time).*

Calculated final ground water concentrations (Cmix), should not exceed maximum contaminant levels. Other appropriate methods may be used. As mentioned in Section 6.6.3.2.3, Figure 2-1,and the appendices provide select aquifer characteristics for input into the equation. The appendix also provides hydraulic conductivity values for various rock types in the eastern Snake River Plain. Site specific values are preferred when possible. It is essential for the user to be familiar with the assumptions of the model to be able to interpret the output. It must be noted that calculations of this sort are a rough estimate, and do not take into account attenuation mechanisms which will certainly take place to varying degrees in the environment. Modifications of these calculations can be made and more sophisticated models used to predict with greater accuracy impacts to the ground water. Other factors that may be considered include: operational period of the facility; decay and degradation; retardation; and adsorption, precipitation and other chemical reactions.

6.6.4 References

EPA, October 1981. Process Design Manual - Land Treatment of Municipal Wastewater, EPA 625/1-81-013.

EPA , March 1991. WHPA: A Modular Semi-Analytical Model for the Delineation of Wellhead Protection Areas - Version 2.0.

EPA, April 2000. Working with WhAEM 2000 – Source Water Assessment for a Glacial Outwash Wellfield, Vincennes, Indiana. Office of Research and Development, Washington D.C. EPA/600/R-00/022.

Freeze, R. A., and J. A. Cherry. 1979. Groundwater. Prentice Hall. 604 p.

Garabedian, S. P., 1989. Hydrology and Digital Simulation of the Regional Aquifer System, East Snake River Plain, Idaho. USGS Open File Report 87237, 140 p.

Idaho Division of Environmental Quality, February 1997. Idaho Wellhead Protection Plan. (DEQ, 1997)

6.7 Site Closure

Permanent site closure of a WLAP site often necessitates a closure plan. The plan should include an environmental assessment of possible adverse impacts resulting from the prior permitted facility and the decommissioning of pumps, storage lagoons and other miscellaneous equipment; the treatment of sludge or wastewater in the lagoons; site restoration; and any necessary corrective actions. Site closure should be discussed as a mutual issue of concern for the WLAP permittee and DEQ. It is critical that the protection of public health and existing and future beneficial uses of the waters of the state are maintained after site closure.

DEQ makes the following recommendations regarding site closure for a wastewater-land application system:

- Site closure should be included as a standard permit condition for each wastewater-land application facility.
- The standard permit condition should include two elements:

(1) Permittee notification of DEQ six months prior to closure or as far in advance of closure as possible; and

(2) A pre-site closure meeting between the permittee and DEQ during which specific closure or clean-up tasks will be identified and time-lines for completion of tasks for both DEQ and the permittee.

- A site closure plan should be developed by the permittee based on the agreements and results of the pre-site closure meeting. The plan should be submitted to DEQ within 45 days after the pre-site closure meeting and finalized with signatory agreement by all parties prior to commencing site closure activities.

In any event, site closure should be included as part of the submittal package for each *new* wastewater land application facility. This same practice is encouraged for each permittee at the time of permit renewal.

6.8 Weed Control at Wastewater Land Treatment Facilities

Weed control is a necessary practice at wastewater land treatment facilities. Facilities should manage their sites to control weeds, including noxious weeds. Procedures to address control of noxious weeds should be included in the facility plan of operation or O&M manual. DEQ should be kept informed of proposed plans to noxious weeds as it may affect the performance of land application sites.

6.8.1 Weed Control – General Considerations

Lagoon areas should be free of weeds. Vegetation surrounding lagoons, if present, should be mowed short. Uncontrolled vegetative growth surrounding lagoons provides habitat for rodents and other undesirable animals which may do damage to the structure of lagoons. Also, such growth may interfere with necessary operation of the lagoons. Weed control is also necessary on wastewater land treatment sites as well. Crops, which beneficially utilize water and nutrients, grow successfully when not in competition with weedy species. It is important for facilities to be aware of Idaho's Noxious Weed Program which is discussed below, to better control weeds and better manage facilities.

6.8.2 Idaho's Noxious Weed Program

The Idaho State Department of Agriculture (ISDA) is responsible for administration of the State Noxious Weed Law. The following website has information regarding noxious weeds found in Idaho, ISDA rules and requirements regarding noxious weeds, county contacts to discuss how to deal with noxious weeds, and other related information.

http://www.agri.state.id.us/animal/weedintro.htm

The frequently asked question~~s~~ (FAQ) section of the Web site provides a general background on noxious weeds in Idaho.

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